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Now you can buy the telescope of a lifetime at a price you probably never thought possible.

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar™ computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. And, at $1695, the 8" LX90 — *with more than twice the light-gathering power* — is priced only a few hundred dollars more than competing *5"* Schmidt-Cassegrains!

Advanced capability incorporating the optical system and coatings of the 8" LX200, and with 5 arc-minute pointing precision in the GO TO mode. An instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

Special LX90 features include: (a) a die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations; (b) *worm gears* of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging; (c) a rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200 models.*

Autostar Computer Controller: The LX90's *standard-equipment* Autostar controller connects to the telescope's control panel and permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:

  13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars sorted by name and SAO catalog numbers; 8 major planets from Mercury to Pluto; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 memory locations for user-defined objects.
- *Automatic GO TO capability* to *any* object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* in either equatorial or altazimuth modes using any of three alignment functions, including the Meade-proprietary Easy Align*.
- *Unlike the hand controllers* included with competing 5" and 8" SCT's, *Autostar is fully upgradeable over the Internet*: the observer can add the positions of new comets, update the positions of Earth satellites, even add new software as it becomes available.

Cordless Operation: The LX 90 is powered at 12 volts DC provided by (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

* Patent pending.

Meade 8" LX90 Schmidt-Cassegrain Telescope. Complete as shown:

$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; operating instructions. **$1695.** Packing & shipping in the 48 states: $95.

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Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
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LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
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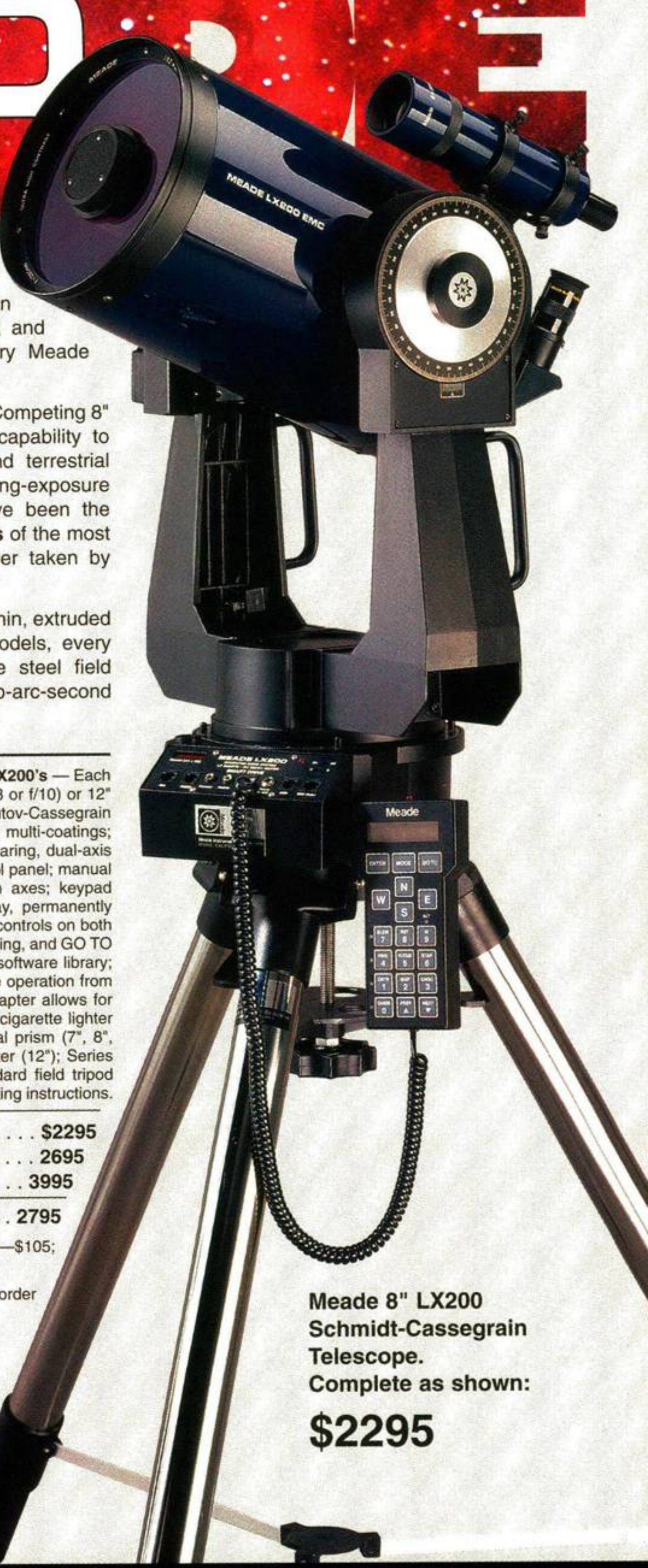
MEADE LX200



The largest-selling serious telescopes in the world are now available at the most affordable prices *ever!*

With their large object databases, fast slewing speeds, and uncanny pointing precision, Meade LX200's are recommended for those amateurs who intend an extensive program of CCD imaging, astrophotography, or deep-space observing. Compare a Meade LX200 feature-for-feature with competing single-tine-fork, spur-gear-driven, GO TO Schmidt-Cassegrains:

Superb Optics: With oversize primary mirrors for greater full-field illumination, LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

Automatic GO TO Capability: Competing 8" Schmidt-Cassegrains claim to place objects "somewhere in the field of view"; Meade LX200's place objects **dead-center** in the field of view, first time, every time, to a pointing precision of **2 arc-minutes or better,** or, with Meade exclusive High Precision Pointing, to a precision of **one arc-minute or better.** *Meade LX200's are the only commercial telescopes ever manufactured that automatically GO TO any input R.A. and Dec., or to any object in the onboard database, to these levels of precision.*

Database of 64,359 Objects, a database *more than three times larger* than competing GO TO telescopes.

Permanently-Programmable Smart Drive™ routinely achieves 5 arc-sec. periodic error, an observatory standard. Other brands of GO TO 8" SCT's decline to state their periodic error and do not offer any programmable error-corrector.

9-Speed Dual-Axis Electronics: Electronics that cover every contingency of telescope positioning — from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, plus 6 other dual-axis drive speeds in between.

Rigid LX200 Dual-Tine Fork Mountings with Dual 5.75" Worm Gears are the choice of advanced observers, CCD imagers, and astrophotographers for their most sensitive applications. Competing spur-gear-driven single-tine forks can not approach the strength, rigidity, and drive-rate precision built into every Meade LX200 mounting.

Full Long-Exposure Capability: Competing 8" GO TO telescopes describe their capability to take short-exposure "planetary and terrestrial photos," without reference to any long-exposure capabilities. Meade LX200's have been the instruments of choice in **thousands** of the most detailed long-exposure images ever taken by amateur astronomers.

Strong Field Tripods: Unlike the thin, extruded aluminum tripods of competing models, every LX200 includes a fully adjustable steel field tripod perfectly suited to the sub-arc-second resolution of the telescope's optics.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2295**
10" LX200 Schmidt-Cassegrain	**2695**
12" LX200 Schmidt-Cassegrain	**3995**
7" LX200 Maksutov-Cassegrain	**2795**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

Prices shown are suggested U.S. mail-order retail prices.

Meade 8" LX200 Schmidt-Cassegrain Telescope. Complete as shown:

$2295

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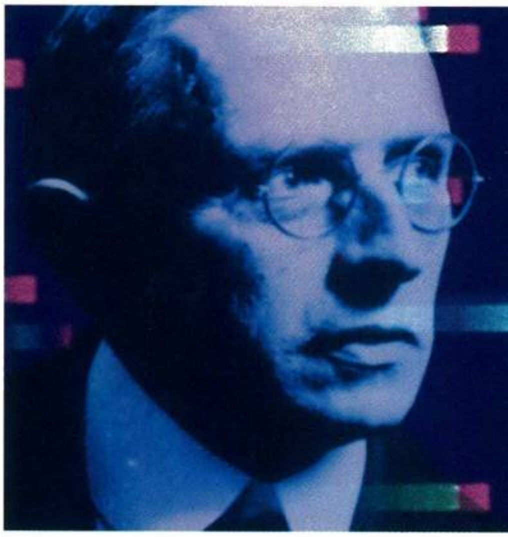

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Stars over Colorado

The *Astronomy* magazine Sky Show, a new kind of star party, will be coming to the Denver area on Friday, October 6. We expect the same sort of delighted stargazers — about 2,000 strong — who visited with us in Davis, California, in August. I also counted 27 dogs and 190 kids. There were at least 85 telescopes and manageable lines at all of them. Meanwhile at Yellowstone National Park, another *Astronomy* magazine star party drew more than 4,000 visitors to look through telescopes set up near Old Faithful and Mammoth Hot Springs. The guests were mainly newcomers to telescope-aided stargazing.

Our goal is to introduce the night sky to many people who have never looked through a telescope before (and share it with many who have). We invite area astronomers to come on out and help us. Bring telescopes and CCDs, binoculars and red lights. Bring a picnic, or wait and buy dinner at an outdoor café on site. Meade Instruments will be a major sponsor of the party in Colorado and bring several new scopes that you may test. Many other exhibitors will be on hand to share and sell their wares. The staff of Astronomy.com will introduce its newly launched website.

Terry Atwood

At *Astronomy* Sky Shows telescope owners will share their equipment with all the guests.

We will have a telescope station focused on the planets, including Mercury, Venus, Jupiter, and Saturn, and all before midnight. We will have a constellation corner and storytellers from *Astronomy* magazine who will talk to you about the night sky's rich mythology. We will have telescopes pointed at one of several entrancing deep-sky objects, including the Dumbbell Nebula and some massive and distant globular clusters. We will send you on your way across our telescope field with a map for guidance, and send you home with literature about each of our telescope targets.

Astronomy staff members have visited many star parties in the summer and fall of 2000. We've been to several nicely and not so nicely attended astronomy conferences. We loved them all, but we had the most fun at our own. We have a new design for star parties and we want to share it with you. Come to Aurora Reservoir, 30 minutes southeast of Denver, at 8 P.M. on Friday night (Saturday in case of rain). You will find the details online at www.geocities.com/starcruizer/seminars/denverskyshow/index or in the astronomy.com pages.

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8" LX10

8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as the more expensive Meade 8" LX200. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently into the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.
$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	195.
Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	375.

Prices shown are suggested U.S. mail-order prices.
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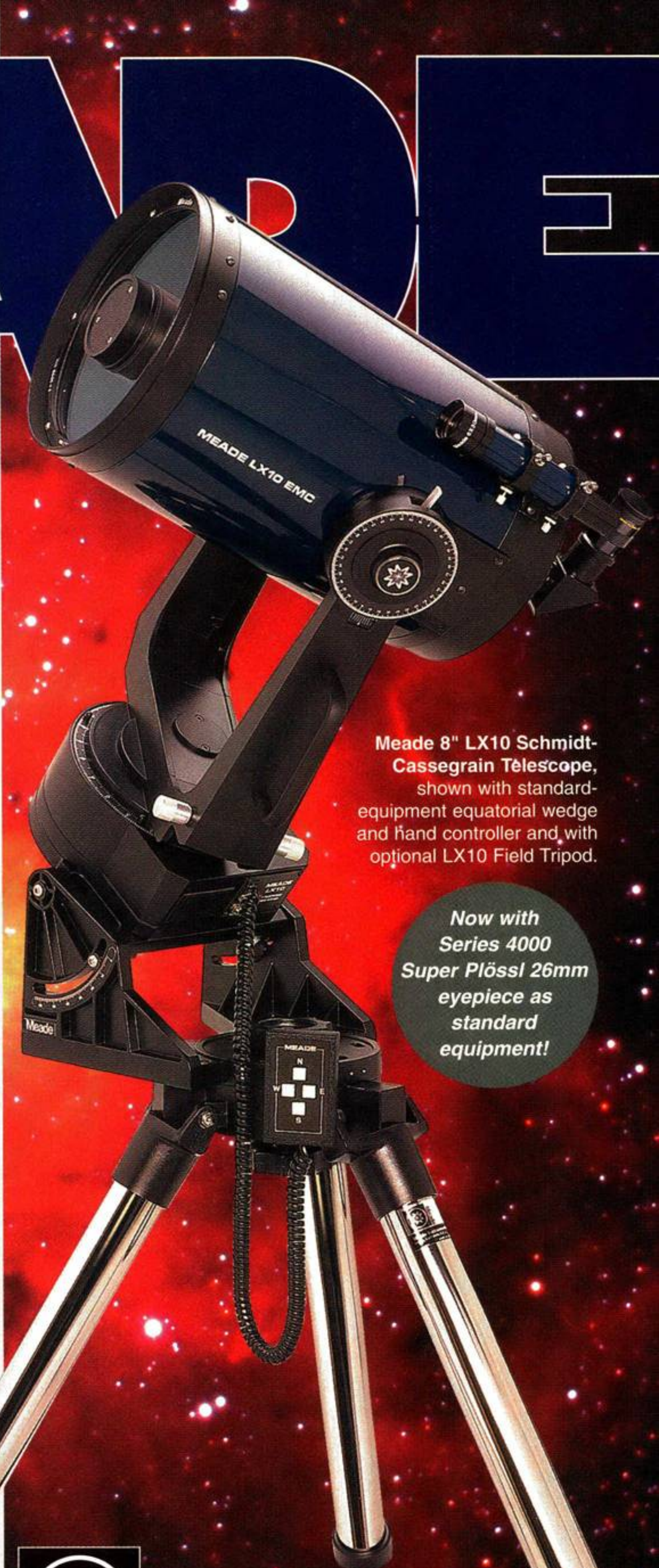

Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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Now you can join the ETX revolution for as little as $299, complete!

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Let Meade high-resolution ETX optics and standard-equipment Autostar controller take you on an automated guided tour of the Solar System, the Galaxy, and beyond. Now even the most novice amateur astronomer can locate and explore the planets, asteroids, and comets, as well as nebulae, star clusters, galaxies, and hundreds of other deep-space objects, at the push of a button.

Fork Mount with Dual-Axis Drive System: In conjunction with the Autostar hand controller, precision worm gear systems on each axis permit smooth pushbutton motions of the telescope, as well as sidereal-rate tracking in the altazimuth mode.

Standard-Equipment #494 Autostar™ Controller: The #494 Autostar includes most of the same features as the more advanced #497 Autostar available for larger Meade ETX models *(facing page)*.

- **Automatic dual-axis GO TO function at 4.5°/sec.** to any of more than 1450 database objects, including the complete Messier and Caldwell deep-space object catalogs, the major planets from Mercury to Neptune, 26 asteroids, 15 periodic comets, and more.
- **Select any of Autostar's** database objects, or any object of known R.A. and Dec, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field of view.
- **Digital readouts** of telescope position, continuously in R.A. and Dec.
- **9-speed Dual-Axis Operation:** Pushbutton control of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 4.5°/sec., plus sidereal-rate tracking.

High-Resolution Achromatic Objective Lenses: ETX 60mm and 70mm models include multi-coated, air-spaced achromatic lenses of exclusive Meade design; each lens yields razor-sharp images of astronomical and terrestrial subjects.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #933 45° Erecting Prism or for photography with the optional #64ST Photo Adapter.

Cordless Operation: The dual-axis drive of Meade ETX-60AT and ETX-70AT models operates for over 20 hours in the field from six AA-size (user-supplied) batteries which store neatly inside the drive base.

Solar System: Saturn
ENTER
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GO TO
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AUTOSTAR
Guided Tour Tonight's Best
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GO TO
SPEED
MEADE
AUTOSTAR
MEADE
MPUTER CONTROL
ON
OFF
AUX

ETX-70AT: $349, complete with #494 Autostar Controller.

ETX-60AT: $299, complete with #494 Autostar Controller

SPECIFICATIONS: ETX-60AT and ETX-70AT Astro Telescopes — Each includes achromatic refractor optical tube assembly (D = 60mm, F = 350mm, f/5.8 *or* D = 70mm, F = 350mm, f/5) with multi-layer optical coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles, and locks on both axes; electronic control panel; 9-speed (2x sidereal through 4.5°/sec.) dual-axis motor drive system with #494 Autostar computer controller; sidereal-rate tracking; internal battery compartment accepting six (user-supplied) AA-size batteries; MA9mm (39X) and MA25mm (14X) multi-coated eyepieces; operating instructions. **ETX-60AT — $299** (+$10 packing & shipping in the 48 states); **ETX-70AT — $349** (+$10 P & S).

OPTIONAL SYSTEMS FOR MEADE ETX TELESCOPES*

#882 Standard Field Tripod (60, 70)	$99.00	#883 Deluxe Field Tripod (90, 125)	199.95
#827 8 x 25mm Right-Angle Viewfinder (60, 70)	49.95	#825 8 x 25mm Right-Angle Viewfinder (90)	49.95
#773 Hard Carry Case (60, 70)	59.95	#774 Hard Carry Case (90)	99.95
#933 45° Erecting Prism (60, 70)	49.95	#775 Hard Carry Case (125)	149.95
#64ST Photo Adapter (60, 70)	19.95	#932 45° Erecting Prism (90, 125)	49.95
#497 Autostar Computer Controller (90, 125)	149.00	#64 Photo Adapter (90, 125)	34.95
#880 Equatorial Table Tripod (90)	29.95	Electric Focuser #1244 (90) *or* #1247 (125)	119.95
#881 Equatorial Table Tripod (125)	59.95		

**see also the Meade accessory ad in this issue.*

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COMPUTER CONTROL
MEADE

ETX-90EC: $595, complete with Electronic Controller

ETX-125EC: $895, complete with Electronic Controller

Two advanced apertures: ETX-90EC — $595 ETX-125EC — $895

Meade® 3.5" and 5" ETX® models include the very latest in microprocessor-controlled capability:

Fork Mount with Dual-Axis Drive System: Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use at any of four dual-axis speeds: 8x for image centering at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Maksutov-Cassegrain Optical Systems: Manufactured at the Meade Irvine, facility, ETX diffraction-limited optics produce images so high in contrast and resolution that ETX telescopes often outperform other telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base.

Optional #497 Autostar™ Capability: Plug in the optional Meade #497 Autostar computer controller for LX200-type operation, including:

- **Automatic dual-axis GO TO function at 5°/sec** to any of more than 14,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; and more.
- Select any of Autostar's database objects, or any object of known R.A. and Dec, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.
- **Digital readouts** of telescope position, continuously in R.A. and Dec.
- **9-Speed Dual-Axis Operation:** Pushbutton control of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec., plus sidereal-rate tracking.

ETX AUTOSTAR
MEADE
ENTER
MODE
GO TO

SPECIFICATIONS: ETX 90EC and ETX-125EC Astro Telescopes — Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 *or* D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) *or* 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); instructions. **ETX-90EC — $595** (+ $20 packing & shipping in the 48 states); **ETX-125EC — $895** (+ $30 P & S).

AUTHORIZED U.S. AND CANADA MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

6001 Oak Canyon, Irvine, CA 92618. (949) 451-1450. FAX: (949) 451-1460. www.meade.com

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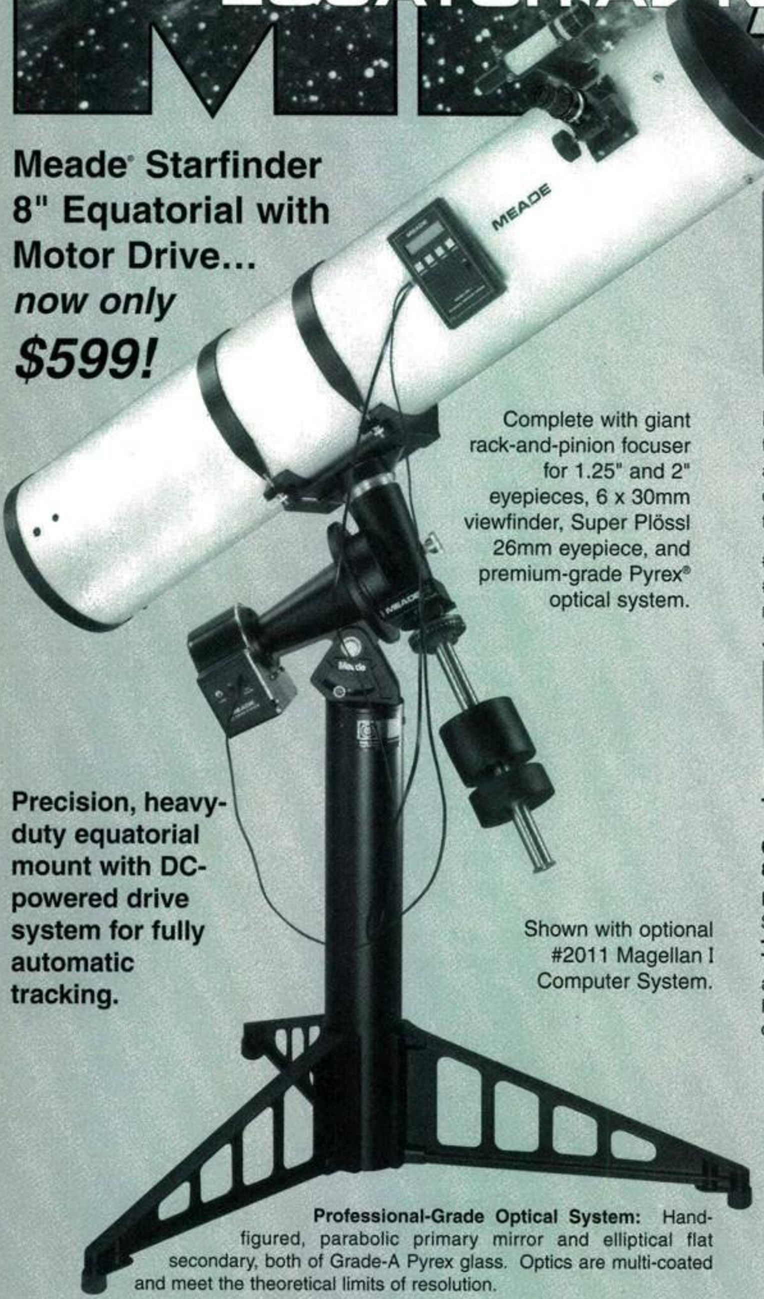
MEADE

STARFINDER™
EQUATORIAL NEWTONIANS



Meade® Starfinder 8" Equatorial with Motor Drive... *now only* ***$599!***

Complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Precision, heavy-duty equatorial mount with DC-powered drive system for fully automatic tracking.

Shown with optional #2011 Magellan I Computer System.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade Starfinder Equatorial 6", 8", or 10" . . . . . $295.
#2012: for Meade Starfinder Equatorial 16". . . . . 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for Starfinder Equatorial 6", 8", 10" . . . . 495.
#2019: for Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

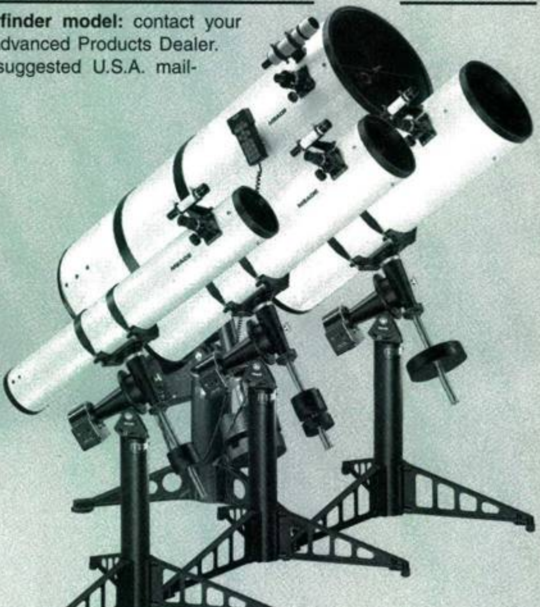
Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

Meade Starfinder Equatorial Telescopes

6" f/8	**$499**	**10" f/4.5**	**699**
8" f/6	**599**	**16" f/4.5**	**2695**

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

To Order any Starfinder model: contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.



New 120-page 2000 Meade General Catalog!

Write, call, or fax Meade Instruments for your free copy.

ADVANCED PRODUCTS DIVISION
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The largest-selling telescopes in the world. ☐ A NASDAQ company.
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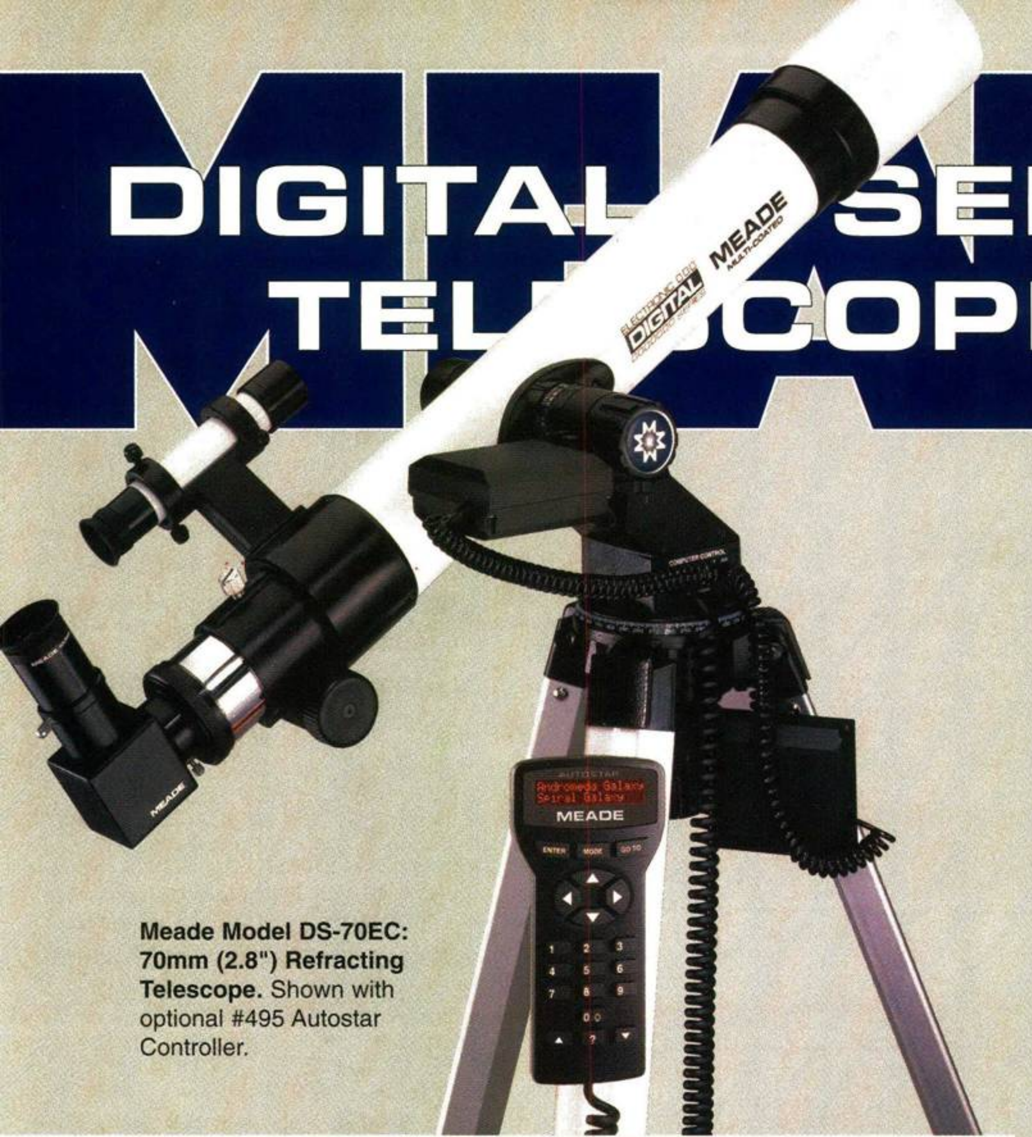
MEADE DIGITAL SERIES TELESCOPES



Meade Model DS-70EC: 70mm (2.8") Refracting Telescope. Shown with optional #495 Autostar Controller.

Meade Digital Series (DS) Telescopes offer the widest range of features ever made available in telescopes of their price class. The standard-equipment Electronic Controller (EC) permits precise pushbutton slewing and tracking at any of four speeds. Available optionally, the #495 Autostar Controller allows for automatic GO TO operation.

Digital Electronic Series Telescopes by Meade®: High Technology, Low Prices.

Now even the beginning or casual observer can enjoy the benefits of the very latest in digital microprocessor technology. Meade Digital Series (DS) telescopes are a revelation of electronic capability, premium-grade optics, and mechanical precision.

Electronic Controller: Use the Electronic Controller, provided as standard equipment with all DS-EC models, at any of four dual-axis speeds from 2 arcmins/second to 6°/second, to center and track astronomical objects at any magnifying power.

Altazimuth Mountings: Engineered for smooth dual-axis tracking, Digital Series altazimuth mounts provide a level of mechanical precision previously unavailable on beginning- and intermediate-aperture telescopes.

Optical Systems: Meade DS refracting telescope models include 2-element mulit-coated achromatic objective lenses, precision polished from crown and flint optical glass components. Newtonian reflecting telescopes of the series include primary and secondary mirrors free of the optical zones and irregularities often found on optics of lesser quality.

Optional #495 Autostar Controller: Plug in the Meade #495 Autostar Controller to the control panel of your DS-EC telescope, and you're ready to locate any of over 1500 celestial objects in the Autostar database, including hundreds of galaxies, nebulae, star clusters, the complete Messier and Caldwell deep-space catalogs, and more — all at the push of the GO TO button.

IN
FOCUS
OUT
SPEED
MODE
MEADE

The standard-equipment Electronic Controller of Meade DS-EC models.

Specifications: Each Meade Digital Series telescope described here is *supplied complete* as shown in the photo below, with aluminum field tripod, two eyepieces (1.25"), diagonal mirror, 5 x 24mm or 6 x 30mm finder, Electronic Controller with dual-axis motors, and battery pack (accepts ten AA-size user-supplied batteries.) *See the Meade General Catalog for complete specifications.*

MEADE DIGITAL SERIES TELESCOPES

DS-60EC: 60mm (2.4") Refractor	$299
DS-70EC: 70mm (2.8") Refractor	349
DS-80EC: 80mm (3.1") Refractor	449
DS-90EC: 90mm (3.5") Refractor	499
DS-114EC: 114mm (4.5") Reflector	399
DS-127EC: 127mm (5.0") Reflector	449
#495 Autostar for any above model	99

Prices shown are suggested U.S. mail-order retail prices.
Patents pending on DS systems architecture and Autostar.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. ☐ *A NASDAQ® company.*
6001 Oak Canyon, Irvine, California 92618 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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Left-to-right: Meade DS-60EC, DS-70EC, DS-80EC, DS-90EC, DS-114EC, DS-127EC

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

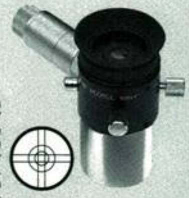
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

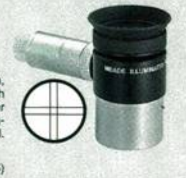
$79.95 (6.85)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

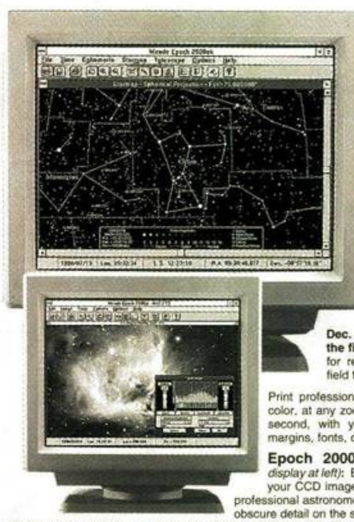
#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

NEW!
MEADE
MEADE

#644

#647

MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 .... **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 .... **$199**

f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

$34.95 (3.86)

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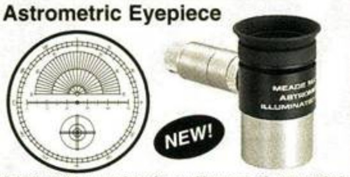

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#775 for ETX-125EC: **149.95** (13.38)

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Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

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Enlistment Bonus

In the August 2000 issue, Bob Berman provided excellent guidelines on how and where to find the best observing sites. In my opinion, however, he missed the best one: Nothing can surpass the magnificence of naked-eye observations from the deck of a blacked-out navy destroyer cruising miles from land. With a 360° horizon and no land to obstruct the sky in any direction, this venue provides the largest area of view. The major drawback is that standing on a moving deck pretty much eliminates using a telescope.

I remember one moonless night when we were at "darkened ship," with only dim red lights visible topside. We were in the middle of a dead calm Indian Ocean. I was standing the midnight watch on the bridge. That particular four-hour watch passed in a heartbeat, as all of us on the bridge drooled at the stars from one end of the sky to the other. It's too bad more people can't experience a sky like that on a regular basis.

Of course, there are other drawbacks, not the least of which requires that one must first enlist. — *Frank P. D'Ascensio, Martinsville, New Jersey*

Beginner's Luck Times Two

On July 28th, while attending the Table Mountain Star Party in Washington, I used the techniques suggested in David Healy's article (June 2000) to capture photos of the aurora borealis. I had never used a manual camera before, and I certainly had never attempted nighttime pictures. Therefore, I was very pleased that Healy's instructions worked. — *Lisa Schmidt, Federal Way, Washington*

Lisa Schmidt

The aurora borealis dazzled skywatchers at the Table Mountain Star Party in Washington.

The July 2000 issue showed asteroid Vesta and how to find it. I never thought I'd locate it because of all the light from Los Angeles. We live up in the coastal mountain area with lots of haze that reflects the city light. To my amazement I found it and followed it for three nights. I'm a beginner and managed to photograph it using a video camera. — *Jim Veronica Jr., Topanga, California*

Spacey Candidates

Which of the two major candidates for President is more likely to support a more robust space program? This info never seems to emerge from the media. I'm hopeful that you can help. — *Harry Mason, Portage, Michigan*

Space funding is not a major issue in the campaign, perhaps because it's not viewed as a high priority by most Americans. A National Science Foundation poll published in July in the New York Times *listed space exploration as second to last in the general public's interest. — Astronomy* editors

Deep-Sky In-Depth

The National Deep Sky Observers Society (NDSOS) is switching from *Betelgeuse* to *The Deep Sky* — a larger, improved format publication. *Astronomy* readers wanting more in-depth deep-sky information or more details about the NDSOS should contact the address below. A sample copy is available by request. Please visit http://www.cismall.com/deepsky/index.html. — *Alan Goldstein, NDSOS Coordinator, 1607 Washington Boulevard, Louisville, KY 40242-3539; e-mail, deepskyspy1@cs.com*

Missing Zero

In "Rounding the Earth" (August 2000) the paragraph on page 43 titled "Earthly Precessions" asserts that 490 earth radii = 194,000 miles. I believe the value is short one zero and should read 1,940,000 miles. — *Philip Schipsi, Cameron Park, California*

Nearly Perfect Performance

I feel that "Missing the Mark" in the July 2000 issue insults the dedicated staff at Lockheed Martin. Both the Mars Climate Orbiter and Polar Lander were crowning achievements of NASA's "faster, better, cheaper" policy. These two spacecraft were built for less, in record time, and performed nearly perfectly.

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The navigational error that doomed the Mars Climate Orbiter was made on the ground. Unfortunately, we will never know why the Polar Lander or Deep Space 2 failed.

Please note that the Lockheed Martin plant in Denver is the prime contractor for the successful Mars Global Surveyor and Stardust missions listed later in the article. Also, both Viking spacecraft that successfully landed on Mars in the 1970s were built at the Denver facility. — *Name withheld upon request, Littleton, Colorado*

"Missing the Mark" was never meant to disparage Lockheed Martin's employees. NASA reports and interviews with scientists suggest that these tragic losses point to management and communication problems beyond Denver — problems that NASA and its indefatigable partners are fixing. — Rex Graham, senior editor

Let's Do Launch

"Reality In Space" in the August 2000 issue stated that Sputnik was launched in 1959. Not so. In 1957, as a radioman on the *USS Lexington*, I had the honor of listening to and recording Sputnik's famous signal. — *J. T. Chancellor, Crooked River Ranch, Oregon*

"Reality in Space" mentioned Neil Armstrong "jouncing along in the moon buggy." No such vehicle was included until the Apollo 15 mission. — *Gary Finiol, Evergreen, Colorado*

Binocular Mount Correction

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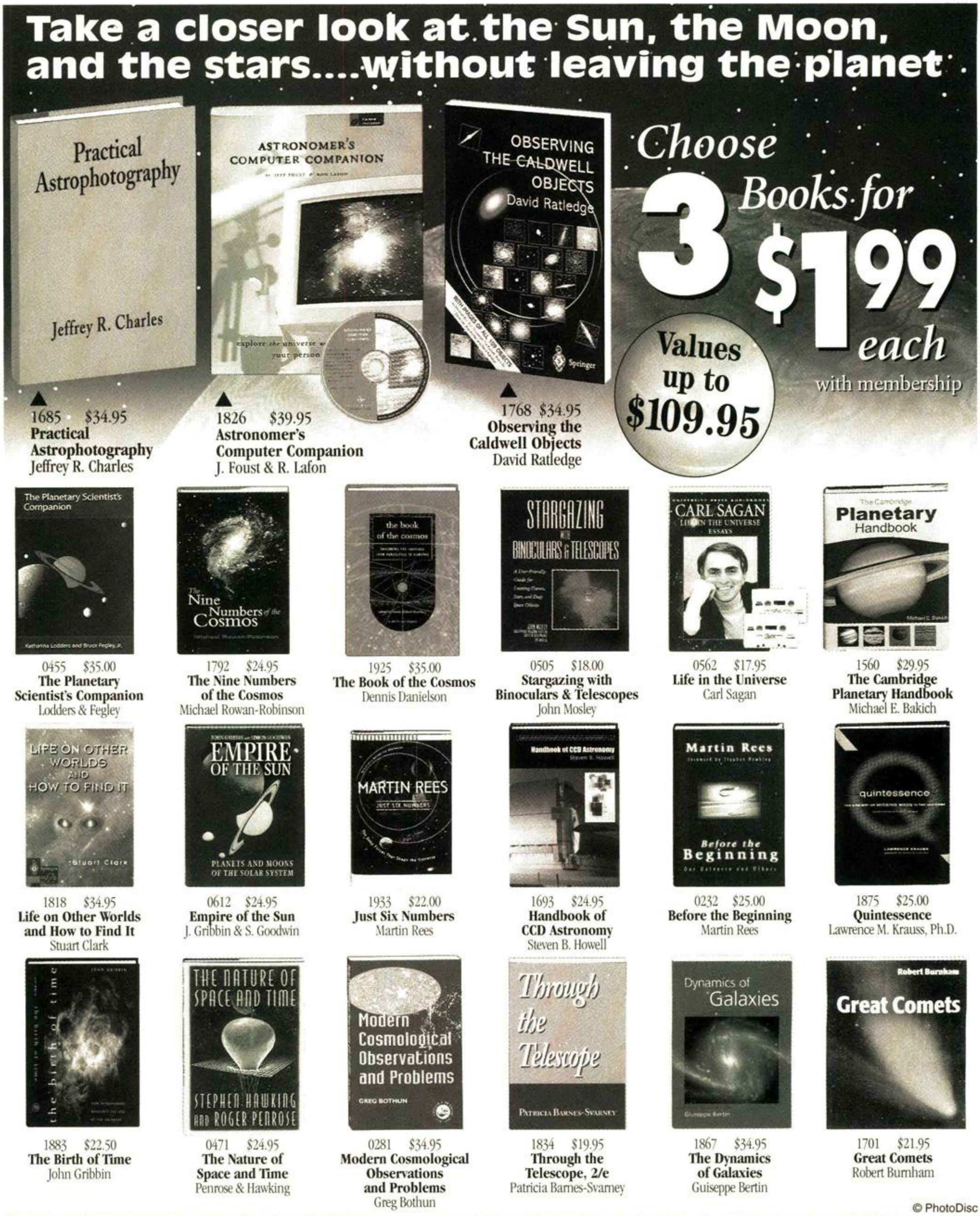
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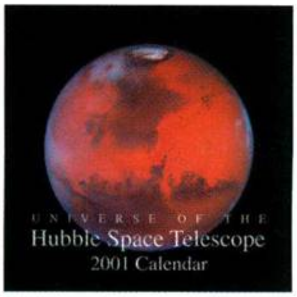
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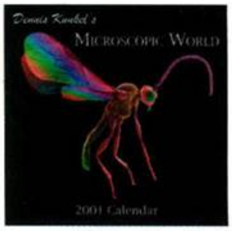
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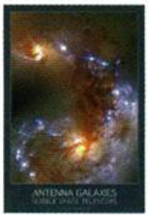
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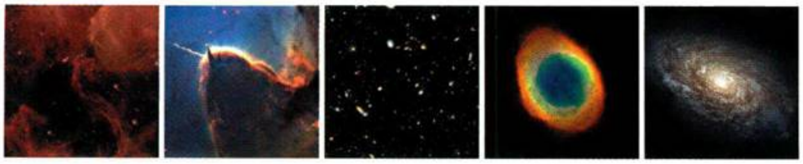

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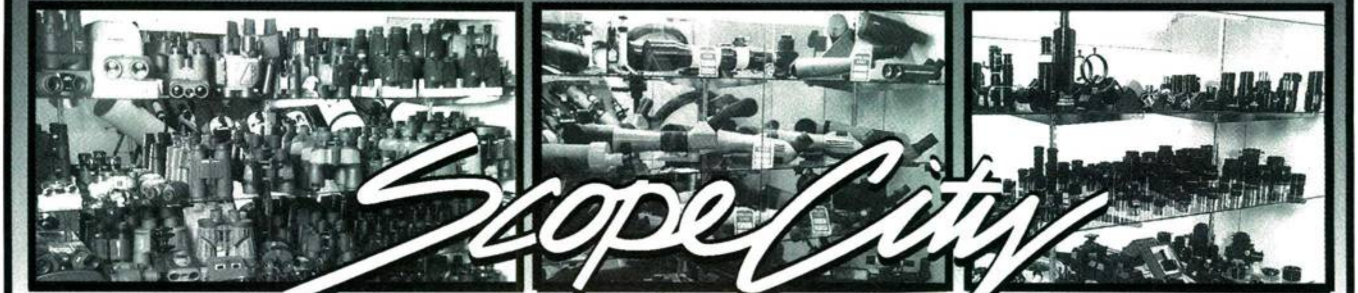

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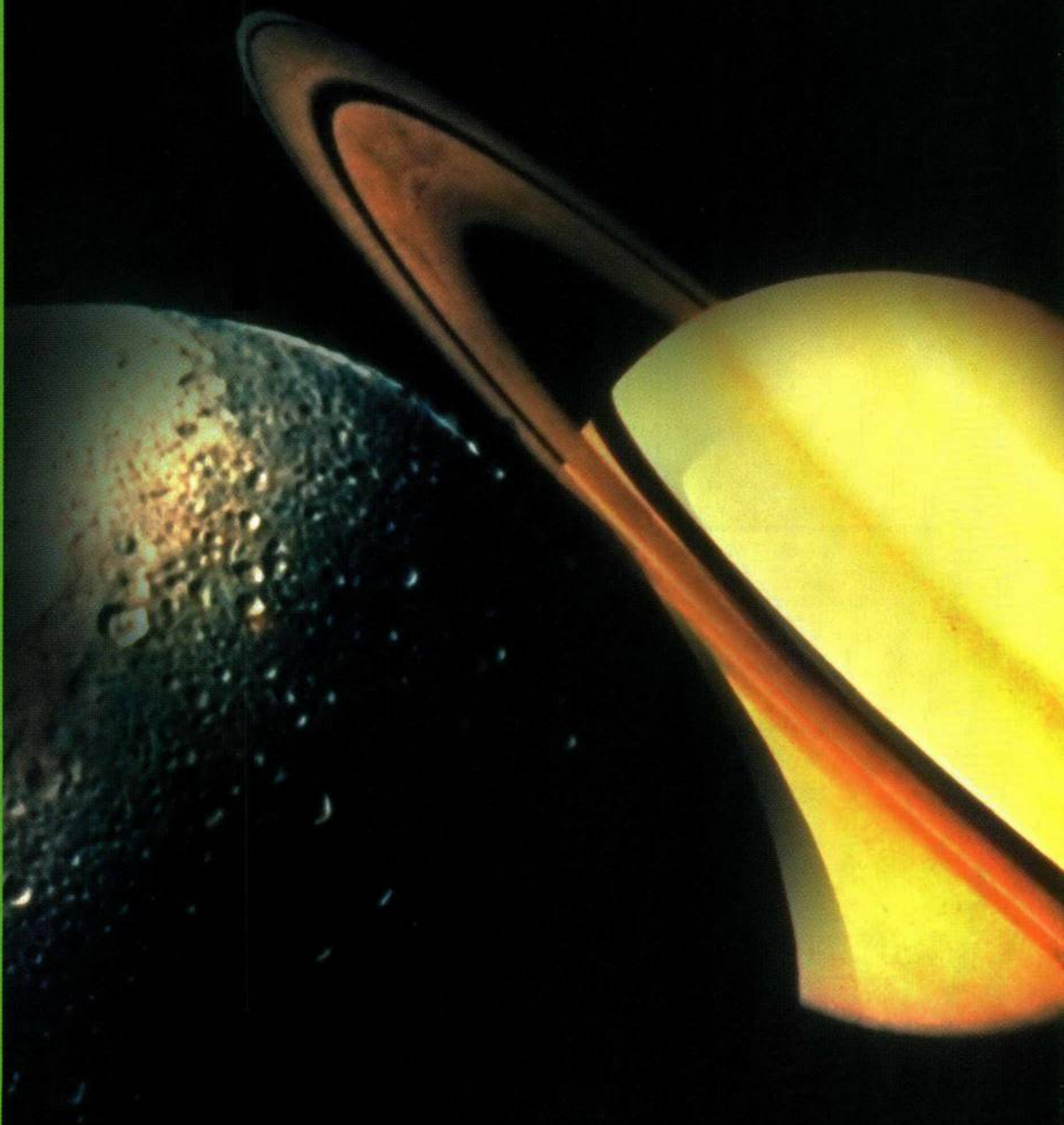

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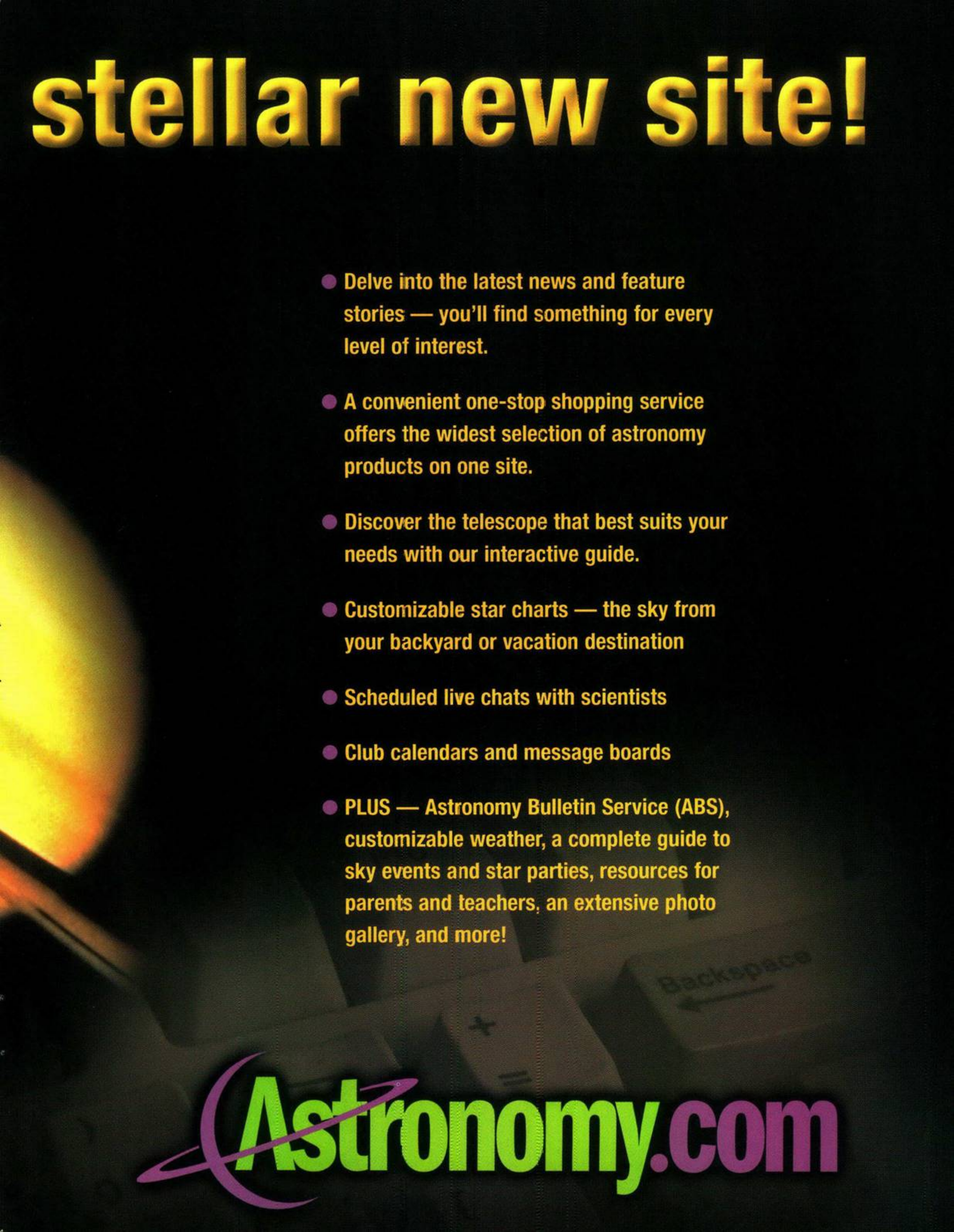

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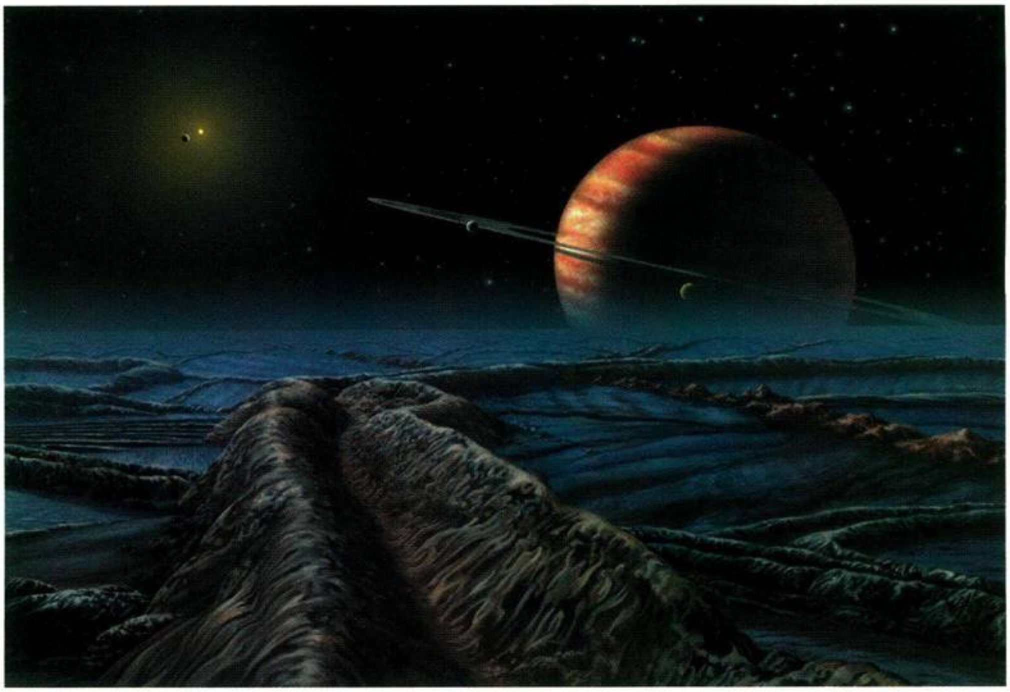
NEW DISCOVERIES

Extrasolar Planets: Fifty and Counting

▶ Ten years ago there were none, now there are more than 50. The number of known extrasolar planets keeps growing like a colony of bacteria in a nutrient-filled petri dish. At the August meeting of the International Astronomical Union (IAU) in Manchester, England, three teams of astronomers announced in a single day the discovery of nine extrasolar planets — as many as the number of planets in our solar system. Included in this batch is the second known extrasolar planetary system around a sunlike star.

One of the new planets orbits the K2 star Epsilon Eridani, which at a distance of 10.5 light-years is the closest single, sunlike star other than the sun itself (Epsilon Eri is slightly smaller and cooler than the sun). Epsilon Eri is also the closest star to the sun known to be orbited by at least one planet. "Detecting a planet orbiting Epsilon Eridani is like finding a planet in our own backyard, relatively speaking," says William Cochran, a member of the discovery team led by his University of Texas colleague Artie Hatzes.



A hypothetical moon circles one of the newly discovered planets orbiting the star HD 38529.

Lynette Cook

Epsilon Eridani's planet has about the same mass as Jupiter and orbits the star on an elliptical path at an average distance of about 3.4 astronomical units (AU), which in our solar system would put it in the asteroid belt. In 1960, radio astronomer Frank Drake targeted Epsilon Eridani, along with Tau Ceti, in humanity's first modern search for extraterrestrial civilizations. But what Drake didn't know at the time is that Epsilon Eri is less than 1 billion years old, meaning the system is almost certainly too young to produce intelligent life.

A team led by Swiss astronomer Michel Mayor has chimed in with six new planets. One of the planets orbits the K0 star HD 83443, which was previously known to have a Saturn-mass planet racing around at 0.04 AU. The new planet, which has a minimum mass only half that of Saturn, may well be the least massive extrasolar planet discovered to date. It orbits HD 83443 on a highly elongated path at an average distance of 0.17 AU.

The American planet-hunting team led by Geoff Marcy and Paul Butler, which has been the most prolific to date, announced three new planets at the IAU meeting (one of which Mayor's team also found). Team member Debra Fischer of the University of California at Berkeley also

THE NINE NEW PLANETS

Star	Type	Distance (LY)	Minimum Mass	Period (days)	Distance from star (AU)	Discovery Team
Epsilon Eridani	K2 V	10.5	0.8	about 2,500	3.4	Hatzes, et al.
HD 6434	G3 IV	131	0.48	22.09	0.15	Mayor, et al.
HD 12661	K0 V	121	2.83	250.2	0.799	Marcy, et al.
HD 19994	F8 V	72	1.8	454.2	1.3	Mayor, et al.
HD 38529	G4 V	138	0.77	14.31	0.129	Marcy, et al.
HD 83443	K0 V	142	0.16	29.83	0.17	Mayor, et al.
HD 92788	G5 V	105	3.86	337.7	0.97	Mayor and Marcy, et al.
HD 121504	G2 V	145	0.89	64.62	0.32	Mayor, et al.
HD 190228	G5 IV	203	5.0	1,127	2.3	Mayor, et al.

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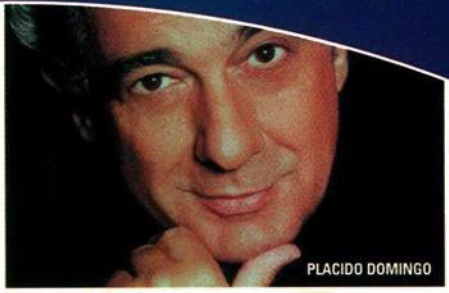
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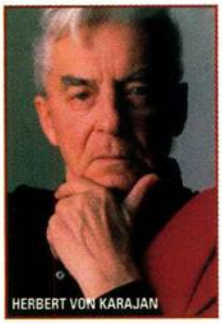
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noted that at least 5 of the 12 planet-bearing stars she has looked at in detail show strong evidence for additional planets. "It's important to know if there are other companions because everything else in the system will affect the dynamics and theories of how the planets moved in and parked in their current orbits," says Fischer.

All nine newly announced planets orbit their host stars between 0.13 and 3.4 AU and have minimum masses between 0.16 and 5 Jupiters. And all have elongated orbits. Like most of the extrasolar planets discovered to date, these planets probably formed farther from their host stars and were slingshot into their current orbits by gravitational interactions with other massive planets. For a table of all the extrasolar planets discovered to date, go to www.astronomy.com.
— Robert Naeye

COMET SCIENCE

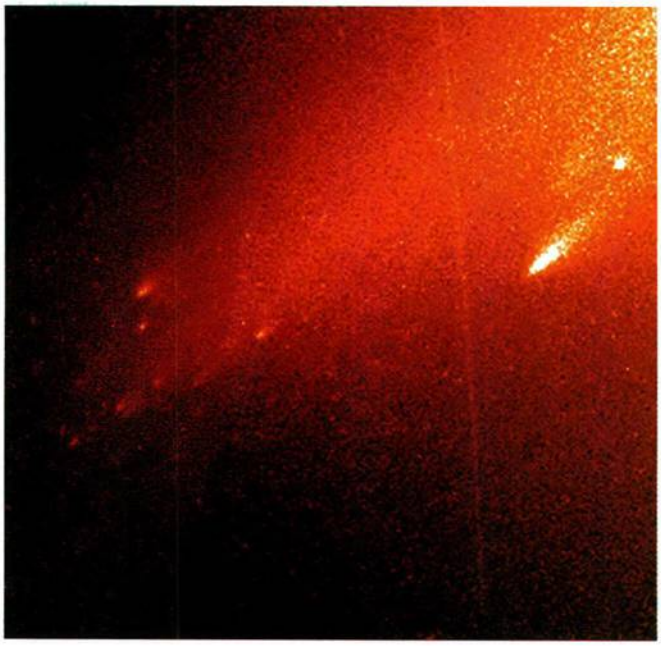
Comet LINEAR Breaks Apart

▶ You might think that surviving for 4.5 billion years would be a good predictor for continued longevity. If you were talking about this past summer's brightest comet, however, you'd be wrong.

After spending billions of years in the outer reaches of the solar system, Comet LINEAR (C/1999 S4) began a slow journey toward the inner solar system. In September 1999, the Lincoln Laboratory Near-Earth Asteroid Research (LINEAR) project discovered it out near the orbit of Jupiter. Quickly astronomers projected its future path and found it would come reasonably close to the sun and Earth in late July 2000, perhaps brightening to 2nd magnitude. Alas, that was not to be. At its best, the comet glowed between magnitude 5.5 and 6.0, barely visible to the naked eye under ideal conditions.

But what ranked as a disappointment to many backyard observers proved a boon to astronomers. For the first time, they got a detailed view of a comet breaking up as the sun warmed its icy nucleus.

The excitement began on July 5, when researchers using Hubble caught the comet blowing off a house-sized piece of its crust. "We lucked out completely," says Harold Weaver of Johns Hopkins University. "In one surge of brilliance this under-performing comet showed us what it could have been. Comet LINEAR has not been as bright as we had hoped, but occasionally it does something exciting."



Hubble imaged half a dozen fragments of Comet LINEAR.
Harold Weaver (JHU), et al., and NASA

That proved an understatement. As the comet rounded the sun in late July, ground-based observations seemed to show the comet breaking up and then totally disintegrating. By July 27, Mark Kidger of the Instituto de Astrofisica de Canarias in the Canary Islands reported that "there is no evidence of any local brightness peaks that would indicate the presence of sub-nuclei."

Astronomers once again turned to Hubble and, on August 5, were delighted when the telescope revealed a shower of glowing mini-comets, each probably no more than 100 feet across. But why did the comet fall apart so easily? Zdenek Sekanina of NASA's Jet Propulsion Laboratory suggests that LINEAR may have been a particularly fragile piece that broke off a much larger comet that passed through the inner solar system millions of years ago. — Richard Talcott

NEAR MISSION

Meteorites Find a Home

▶ Astronomers who study the sun have welcomed the ongoing solar maximum — with its increase in sunspots, flares, and other activity — as a way to probe the inner workings of our star. Yet planetary scientists were taken aback when the sun's activity played a key role in solving one of their most perplexing mysteries: Where do the most common meteorites originate?

It doesn't take a genius to suggest that asteroids could be the source. Tens of thousands of these rocky objects populate the inner solar system, most between the orbits of Mars and Jupiter. The inevitable collisions should release a torrent of meteoroids, many destined to fall to Earth.

Yet the most common meteorites don't appear much like the most common asteroids. The colors of ordinary chondrite meteorites, thought to be the most primitive rocks in the solar system, don't match those of S-type asteroids.

That's where the NEAR Shoemaker spacecraft and the sun's activity came into play. Orbiting the S-type near-Earth asteroid Eros since February, NEAR Shoemaker was perfectly positioned when a mammoth solar flare erupted on May 4. For 30 minutes, x rays from the powerful flare blasted the surface of Eros, causing the elements there to emit their own x rays. The spacecraft's X-ray/Gamma-ray Spectrometer (XGRS) analyzed the intensity of the x rays at

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by Joshua Roth – Sky & Telescope, March 2000

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different wavelengths and got a fingerprint of the asteroid's composition.

Planetary scientists found that Eros appears to be made of the same material as ordinary chondrites. "Chondrites are the building blocks of terrestrial planets," says Tim McCoy of the Smithsonian Institution's National Museum of Natural History, a member of the XGRS team. "If more data confirm Eros is primordial, Eros will be a link between the chondrite meteorites found on Earth and the history of the solar system's formation."

But if Eros and other S-type asteroids are the source of chondrites, what causes the color difference? Researchers now believe that space weathering — the constant bombardment of objects by micrometeorites and particles of the solar wind — can significantly redden the surfaces of asteroids, just as it seems to do to the moon's soil.

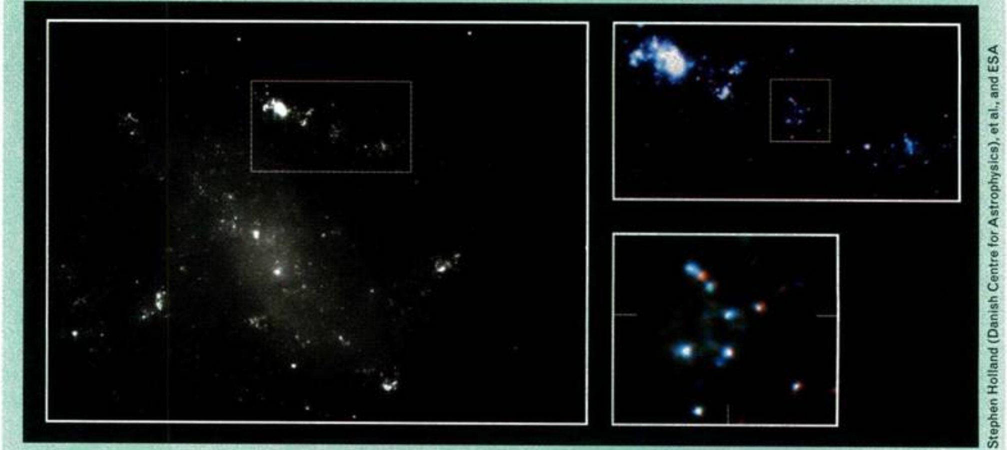
NEAR Shoemaker continues to return images and other observations of Eros from its unique vantage point. It was in an orbit just 31 miles (50 km) from the asteroid's center at the time of the May solar flare. That was lowered briefly to 22 miles (35 km) in July and then raised again to 31 miles. Higher orbits were planned later in the year to view parts of Eros hidden in shadows. — R. T.

Space-weathered rock appears reddish in this false-color image of Eros; blue shows fresher material.

The skyline on this oddly shaped object plays tricks on our senses.

Both photos: Johns Hopkins University and NASA

HUBBLE SPACE TELESCOPE



Stephen Holland (Danish Centre for Astrophysics), et al., and ESA

ASTRONOMERS FINALLY CLAIM VICTORY in a cosmic game of hide-and-seek. For the first time, researchers using the Hubble Space Telescope have taken high-resolution images of a galaxy housing one of the most puzzling phenomena known to astronomers: a gamma-ray burst. Until now, the locations of gamma-ray bursts — very intense, short-lived events that emit lots of high-energy gamma rays — have been pinned down only to the nearest galaxy. This past June, astronomers managed to trace GRB 980425, a burst that occurred on April 25, 1998, to a star-forming region in an arm of the spiral galaxy ESO 184–G82. (These Hubble images, viewed clockwise from left, zero in on this region.) An unusually bright supernova seen in the same location one day after the gamma-ray burst suggests a connection between the two violent events.

PULSARS

Neutron Stars with a Wobble

▶ If you look in most any astronomy textbook, the formation of a neutron star goes something like this: When the core of a massive star runs out of nuclear fuel, gravity causes it to collapse into a ball about the width a major city. The resulting collapse and subsequent rebound triggers a brilliant supernova that can be seen across billions of light-years. But the collapsed core remains. With 1 to 3 suns of matter packed into such a tiny volume, gravity scrunches the atomic matter into an absolutely perfect sphere of neutrons.

But according to a paper published in the August 3, 2000, *Nature*, the textbooks will have to be revised. At least one neutron star, and possibly many more, is slightly aspherical.

Ingrid Stairs, Andrew Lyne, and Setnam Shemar of the University of Manchester made the discovery after observing pulsar B1828–11 for 13 years with the 76-meter Lovell radio telescope at Jodrell Bank, England. The pulsar spins on its axis 2.5 times every second. But the long-term observations also show that it wobbles regularly with periods of approximately 250, 500, and 1,000 days. The wobble is similar to the precession of a spinning top.

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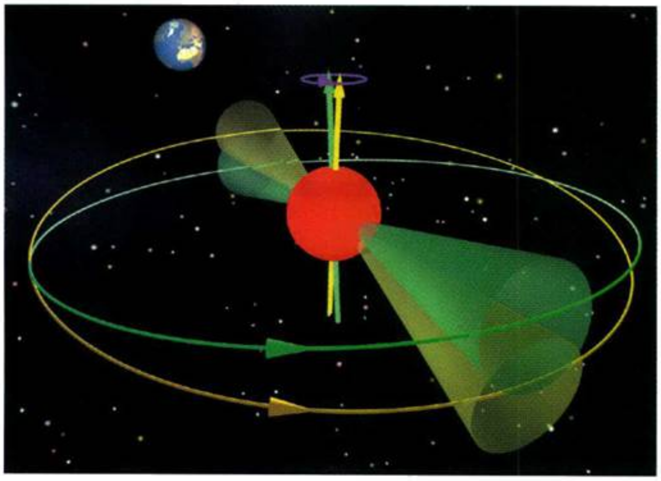


M. Kramer

The pulsar B1828–11 wobbles as it spins because it is not a perfect sphere, causing its rotation axis to follow a circular motion over time. The motion mimics the wobble seen in a gyroscope or spinning top.

the characteristics of the pulses change with time. Second, the timing between pulses varies.

The wobbles imply that the pulsar is not a perfect sphere. Instead, it is slightly squashed, which causes a slight change in the angle between the rotation axis and the radio beam.

But don't expect to find Mt. Everest on the surface of B1828–11. "This star departs from being a perfect sphere by only 0.1 millimeter (0.004 inch) in 20 kilometers (12 miles)," says Lyne. "On Earth, this would mean that no mountain could be higher than 3 centimeters (1 inch)!"

In and of itself, the asphericity isn't that surprising. Any rotating body, such as Earth, naturally develops a bulge around its equator. A neutron star, however, possesses a solid crust and an interior consisting of neutrons in a superfluid state. Theorists predict that the interaction between these two regions should be so strong that any wobble would die out within a few minutes — not persist for several years.

No other pulsar has been seen to wobble like B1828–11, though that may simply reflect a lack of data. "It may well be that longer-term, regular observations will turn up evidence of similar wobbles in other pulsars," says Stairs.

In other pulsar news, a team of American and Japanese astronomers using the Rossi X-ray Timing Explorer satellite have found the youngest pulsar ever seen. The pulsar sits in the middle of supernova remnant Kes 75, which is about 700 years old.

Surprisingly, the Kes 75 pulsar spins "only" 3 times per second. In contrast, the pulsar at the center of the Crab Nebula, which is nearly 1,000 years old, spins 30 times a second. According to current theory, pulsars' powerful magnetic fields should act like a brake, causing them to spin down over time. For some reason, the Kes 75 pulsar is spinning down at a much faster rate, probably because its magnetic field is 10 times more powerful than the Crab's pulsar. — R. N.

SPACE SCIENCE

Cluster Launch a Success

▶ On July 14, 2000, a violent solar eruption completely shut down shortwave communications on Earth and a huge cloud produced by the resulting coronal mass ejection hit the magnetosphere, the magnetic, teardrop-shaped bubble surrounding Earth.

Most charged particles from the sun, known as the solar wind, flow around this bubble and form a long wake called the magnetotail. The July 14 gust of solar wind compressed the magnetosphere, causing magnetic storms and disturbances in power grids on Earth.

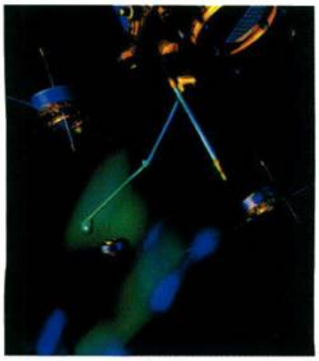
"This is exactly what we hope to observe . . . how the magnetosphere is deformed," says Philippe Escoubet, project scientist for the Cluster mission at the European Space Agency (ESA). ESA launched four identical satellites in pairs on July 16 and August 9 from the Baikonour Space Center in Kazakhstan. ESA's first attempt to launch the mission ended disastrously in June 1996 when the new European heavy-duty launcher, Ariane 5, which carried the satellites, exploded shortly after take-off during its maiden flight. The current mission used two Russian Soyuz launchers to place the spacecraft in Earth orbit.

Because the four satellites will watch simultaneously, they will provide an unprecedented three-dimensional view of the electrical and magnetic phenomena that take place in the magnetosphere. The satellites, named Samba, Salsa, Rumba, and Tango, will dance around Earth at the four corners of a huge tetrahedron. This will allow astronomers to "separate spatial versus temporal changes in the Earth's magnetic field," explains Cluster coinvestigator Patricia Reiff of Rice University in Houston, Texas.

Each satellite contains eleven identical instruments, one of which is American. Some of them will probe the space around Earth directly, sampling particles and the magnetic and electric fields. By changing the distance between the spacecraft several times during the mission, researchers will be able to study different parts of the magnetosphere, including especially turbulent regions caused by the solar wind that can lead to spectacular aurorae. The mission is expected to last up to three years.

About 150 participating scientists are now gearing up to observe the effects of the imminent solar maximum on the magnetosphere. "We expect to see more and stronger storms," says Reiff. And it looks like the storm of mid-July was the starting shot. — Alexander Hellemans

The four spacecraft of the Cluster armada will work in concert to study Earth's magnetosphere.



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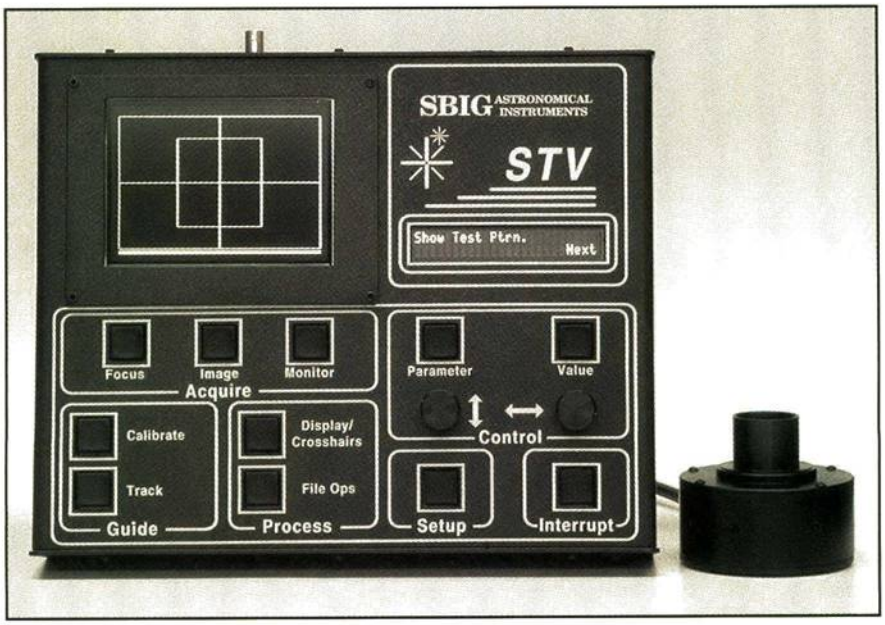
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FUTURE OF ASTRONOMY

Astronomers Look Ahead

▶ The beginning of a new year prompts many people to make lofty resolutions, setting goals they'd like to accomplish in the coming year. Astronomers are no different. Yet they have recently taken a longer view, looking a decade into the future to judge which areas of research deserve the highest priority and — just as important — the most money.

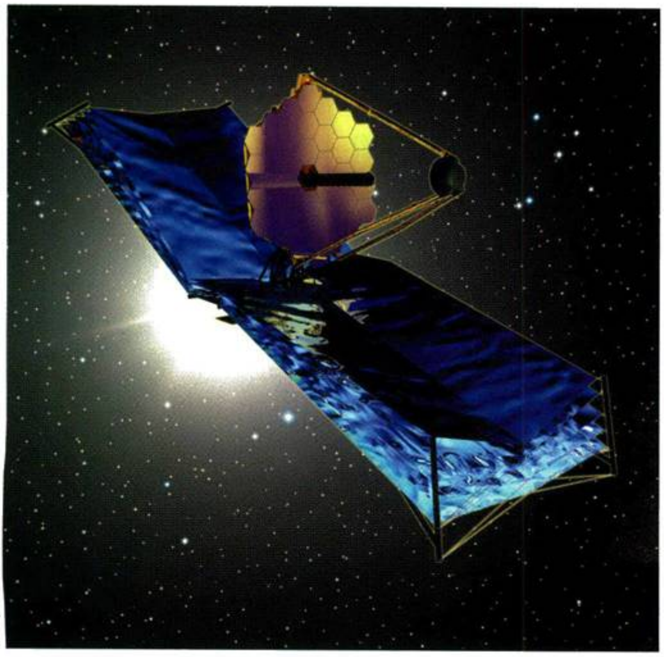
A committee of astronomers led by Joseph Taylor of Princeton University and Christopher McKee of the University of California at Berkeley laid out a vision for the future in a report for the National Research Council of the National Academies. To no one's surprise, the Next Generation Space Telescope topped the list of priorities. With an 8-meter mirror optimized for viewing in the infrared, NGST would be 100 times as sensitive as either Hubble or the Space Infrared Telescope Facility and would provide images 10 times sharper. The giant telescope would shed new light on how the first stars and galaxies formed billions of years ago.

The committee didn't neglect ground-based astronomy, calling for the development of the Giant Segmented Mirror Telescope. This behemoth would have a mirror measuring some 30 meters across — giving it about 10 times the light-gathering power of each Keck Telescope — and would prove invaluable in tracing the evolution of galaxies. The astronomers want to start developing the technology immediately, with construction beginning by decade's end.

Many other major projects are slated to receive high priority. Among these are the Constellation-X Observatory — a set of four x-ray telescopes orbiting in separate spacecraft — intended to study the birth and evolution of black holes, an expansion of the Very Large Array radio telescope in New Mexico by adding eight new antennae, and a large ground-based survey telescope for cataloging 90 percent of the near-Earth objects larger than 1,000 feet (300 meters) in diameter.

The Terrestrial Planet Finder likewise finds itself high on the list. This ambitious unmanned spacecraft will seek and study Earth-like planets around nearby stars and search for evidence of life.

In addition to these large programs, a host of moderate-sized and small initiatives also made the grade. The entire report can be found on the world wide web at http://national-academies.org. If even part of the committee's recommendations come to pass, the next 10 years should prove exciting. — R. T.



The Next Generation Space Telescope ranks as astronomers' top priority for the coming decade.

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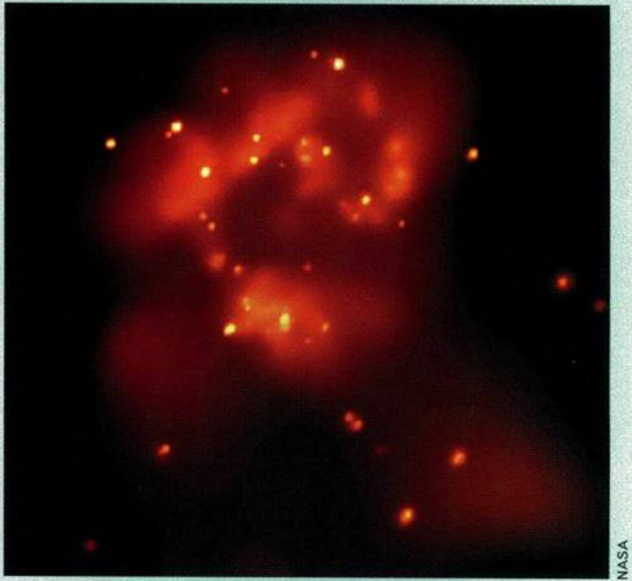
CHANDRA OBSERVATORY



NASA

BUBBLES OF HOT GAS BUMP into one another in the Antennae Galaxies, producing immense "superbubbles" that emit copious x rays. The Chandra X-Ray Observatory captured all the superheated action in this pair of merging galaxies located some 50 million light-years away in Corvus. When galaxies collide and merge, the stars within them typically remain unaffected — they're simply too small and separated by too much space. The same can't be said for the giant clouds of gas and dust that populate the galaxies. They often ram one another, and the collisions lead to rapid star formation. Within a few million years, the biggest of these stars explode as supernovae. The expanding supernova remnants eventually collide and coalesce, forming the giant superbubbles, some 5,000 light-years across, that show up in this Chandra image.

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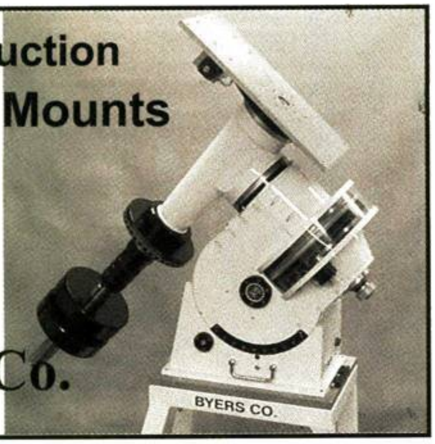

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MARS EXPLORATION

Twin Rovers Now Planned

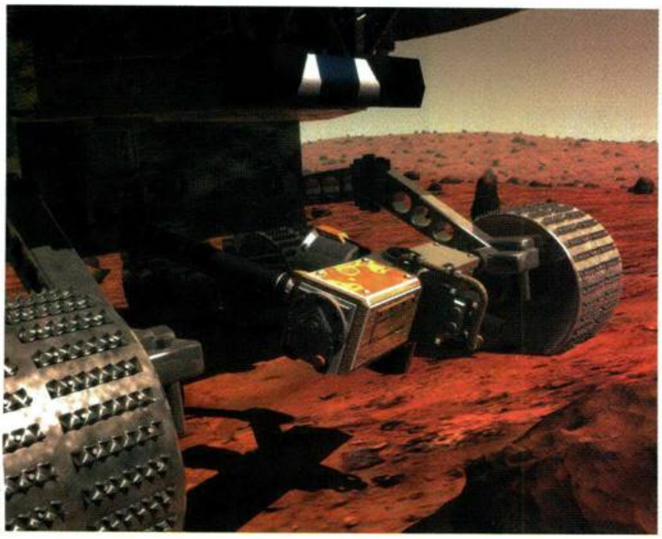
▶ Despite recent troubles in getting spacecraft to Mars, NASA has announced an ambitious plan to explore the Red Planet. And the ambition seems to know no bounds. Less than one month after declaring its intent to send a rover to Mars in 2003, NASA decided that two rovers would be better than one.

NASA decided to take advantage of the excellent launch opportunity in 2003, when Mars will be closer to Earth than at any time in the past 1,000 years. That means it takes less fuel to send the same amount of weight — a chance to get more science for the money. Both rovers will be launched on Delta II rockets from Cape Canaveral in the late spring of 2003. After cruising for seven-and-a-half months, the first rover should enter Mars's atmosphere on January 4, 2004, with the second arriving on January 20. Both will bounce and roll to a stop using the same technology that successfully brought Mars Pathfinder to the surface in 1997.

The rovers will be identical twins, but that doesn't mean they'll simply duplicate each other. The two will be targeted to different locations, where they will each look for evidence of recent liquid water, an idea that has fired human imagination for generations. Recent evidence from Mars Global Surveyor (see AstroNews, October 2000) hints strongly that water may lurk just beneath the martian surface.

Each mobile laboratory weighs about 300 pounds (on Earth) and is expected to last in the harsh environment for approximately 3 months. NASA scientists and engineers are conducting an intensive search for potential touchdown sites, looking for compelling landing zones that also present the fewest hazards. — R. T.

NASA plans to send two rovers to Mars in 2003. To view a video of one rover exploring the martian surface, check out *Astronomy*'s new website, debuting October 2 at www.astronomy.com.



NASA/JPL

New Moons in the News

Astronomers have now added one new moon to the stable of planetary satellites and officially recognized the existence of three others. Last month we reported on the likely discovery of a new moon circling Jupiter. Discovered by the University of Arizona's Spacewatch Project, S/1999 J1 was just waiting for confirmation. That came on July 25, 2000, when astronomers using the 2.2-meter telescope at the European Southern Observatory's La Silla facility recovered the object. The new moon moves in a slightly elliptical orbit at an average distance of 15.0 million miles (24.2 million km) from Jupiter and takes just over two years to complete one orbit. Farther out in the solar system, Uranus now can claim three more official moons. At the International Astronomical Union meeting in England this past August, astronomers formally adopted the names Prospero, Setebos, and Stephano.

Astronomers Get Part of Radio Spectrum

Radio astronomers that probe the millimeter-wave region of the spectrum — studying how stars form and the nature of the interstellar medium — have won a crucial protection for their science. At the World Radiocommunication Conference in Istanbul, Turkey, this past June, delegates gave final approval to a plan that sets aside a broad range of the radio spectrum between 71 and 275 gigahertz. From now on, radio services both on Earth and those using orbiting satellites can only transmit in this region as long as they don't hinder astronomers' attempts to catch faint signals from the cosmos.

Black Hole Devours Its Surroundings

A supermassive black hole at the center of the nearby galaxy NGC 4438 appears to be blowing a bubble of hot gas as it swallows material from its surroundings. The hot bubbles (seen as reddish blobs) result from the black hole's voracious appetite for the gas in its accretion disk (the white region below the bubble). Some of this material is spewed from the disk as twin jets head in opposite directions. The jets eventually slam into a wall of dense, slow-moving gas, and it's this collision that creates the glowing material. The bubbles will continue to expand and will one day dissipate, a short chapter in the long history of this galaxy. The brighter bubble measures 800 light-years tall and 800 light-years across.

J. Kenney and E. Yale (Yale Univ.) and NASA

A black hole at the center of NGC 4438 blows a bubble of hot gas.

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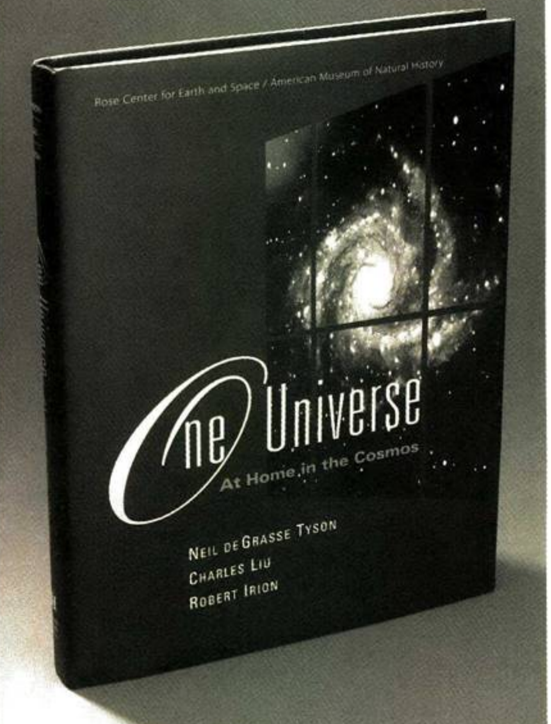

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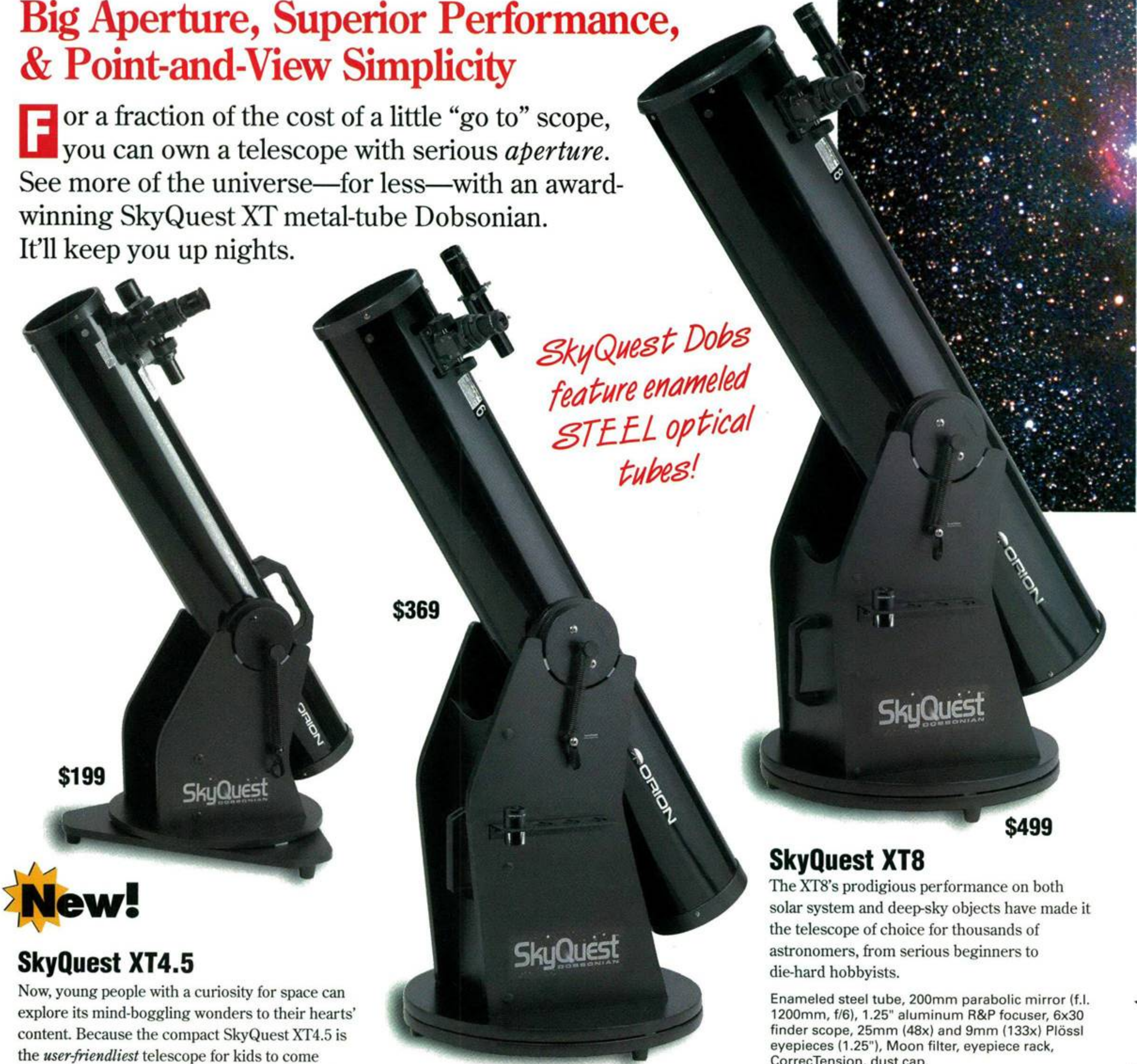

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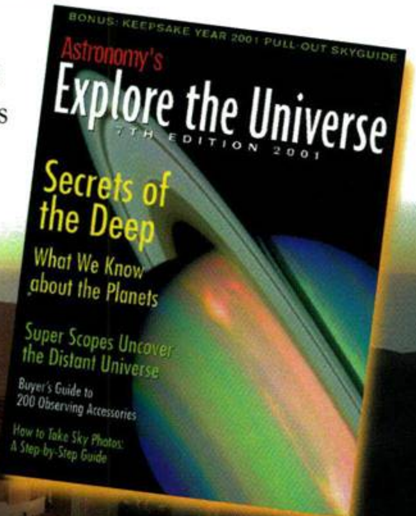

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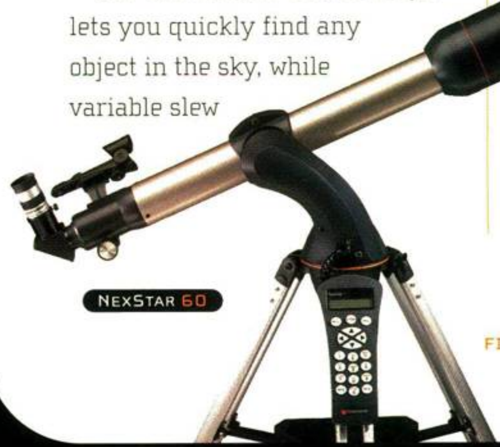

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FREEZE FRAME

Jay Ouellet's astrophotography doesn't end when the mercury drops below zero.

Text by Kelly Kizer Whitt
Photography by Jay Ouellet

On March 9, 1997, Jay Ouellet journeyed out into the frigid, northern winter air to capture a new interplanetary wanderer, Comet Hale-Bopp. While other Canadians were tucked warmly in their beds, he was standing outside in –44° F weather at 3:15 in the morning, struggling to take a 15-minute exposure of the comet. The focuser knob spun freely, and his frozen fingers labored to tighten the knurled screws. He attempted a second picture, but 10 minutes into the exposure he realized that he had stopped guiding and was staring at the snowbank in front of him. The numbing cold was paralyzing all his senses, including his mind.

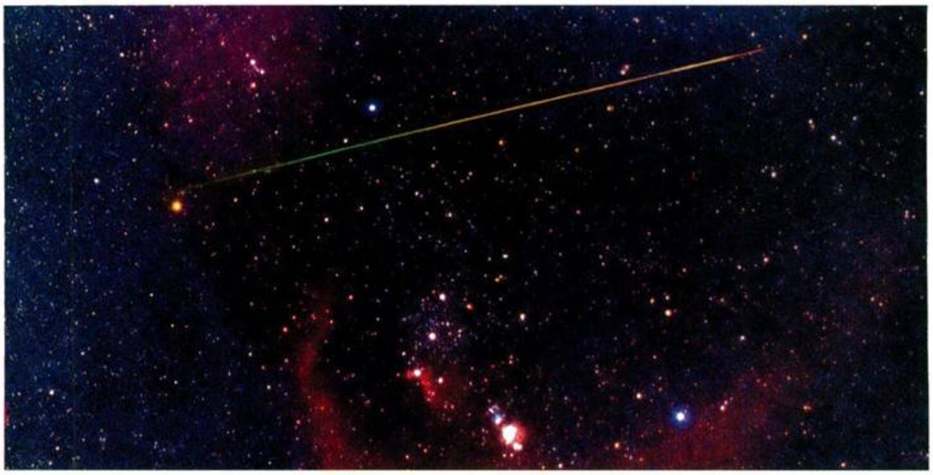
This third-quarter moon image was a black-and-white negative sandwiched with an unexposed processed color negative, which was then printed and scanned.
(5-inch refractor at f/12, Kodak Tech-Pan film, 2-second exposure)

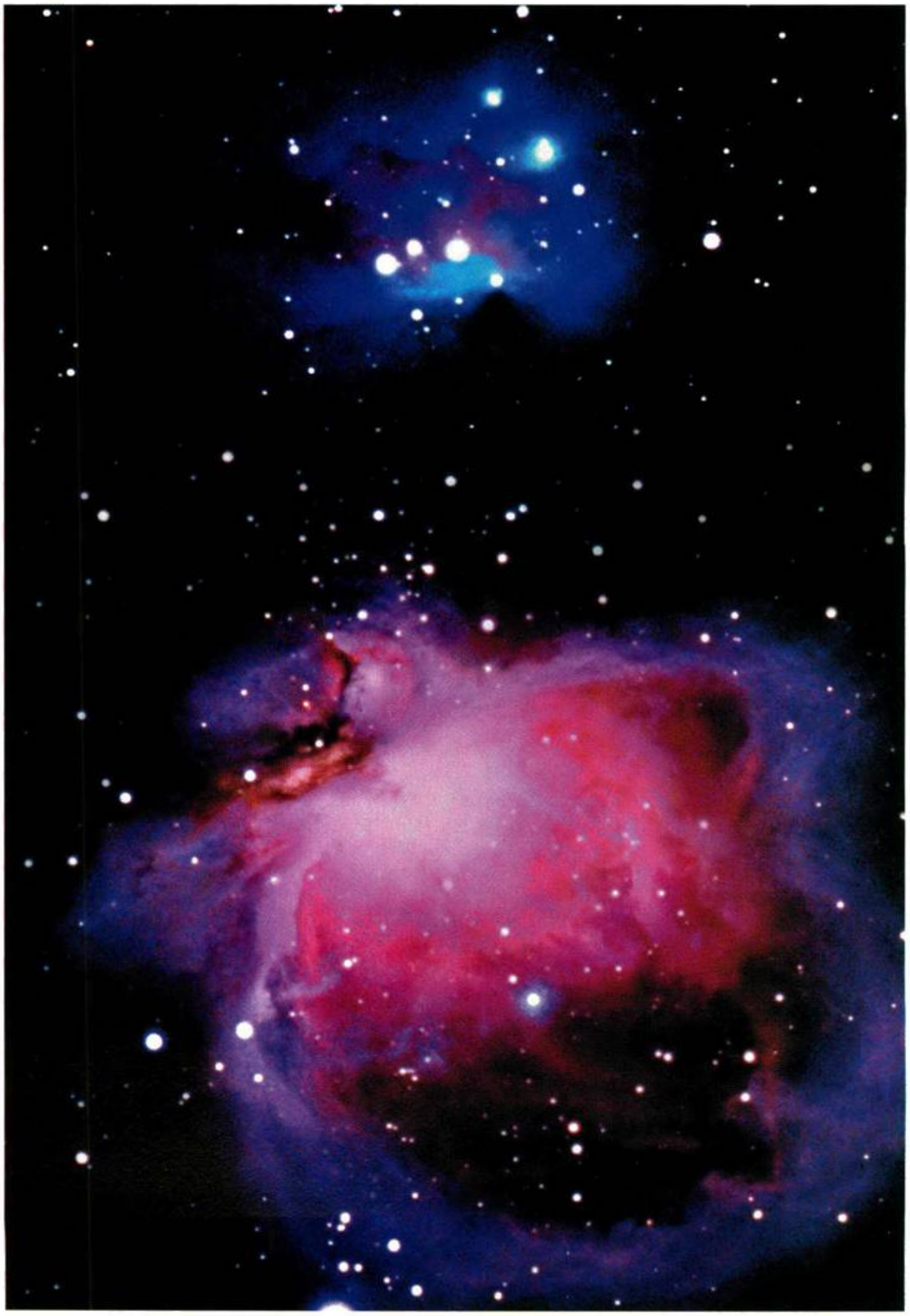
Winter months bring calm skies, but the farther north you live the more dedicated an observer you have to be to stand in the thick snow, hunched up by your telescope. Catching a planetary conjunction on the ride home from work during the longer dark hours of winter or stealing a peak at the moon as we rush to take the garbage out is all the observing many of us are willing to do when temperatures plummet to below freezing.

The dedication of Ouellet could put many of us fair-weather observers to shame. He drives three hours round-trip to a dark-sky site, transporting his 125-pound equipment. Ouellet lives in Quebec City, Canada. With a population of 700,000, Quebec City sits near the 47th parallel and is about a two-and-a-half-hour drive north of Montreal.

A chiropractor by profession, Ouellet has been interested in astronomy for years. From the age of 10, he dreamed of taking pictures of the stars. At 13, he gave his first talk on astrophotography at a weekend camp for teenagers. Thirty years later, Ouellet took his first astronomical photo. Over the past three years, with the help of excellent equipment and under the tutelage of Jerry Lodriguss, Michael Stecker, Tony Hallas, and Terence Dickinson, he has produced night-sky images bursting with vibrant colors.

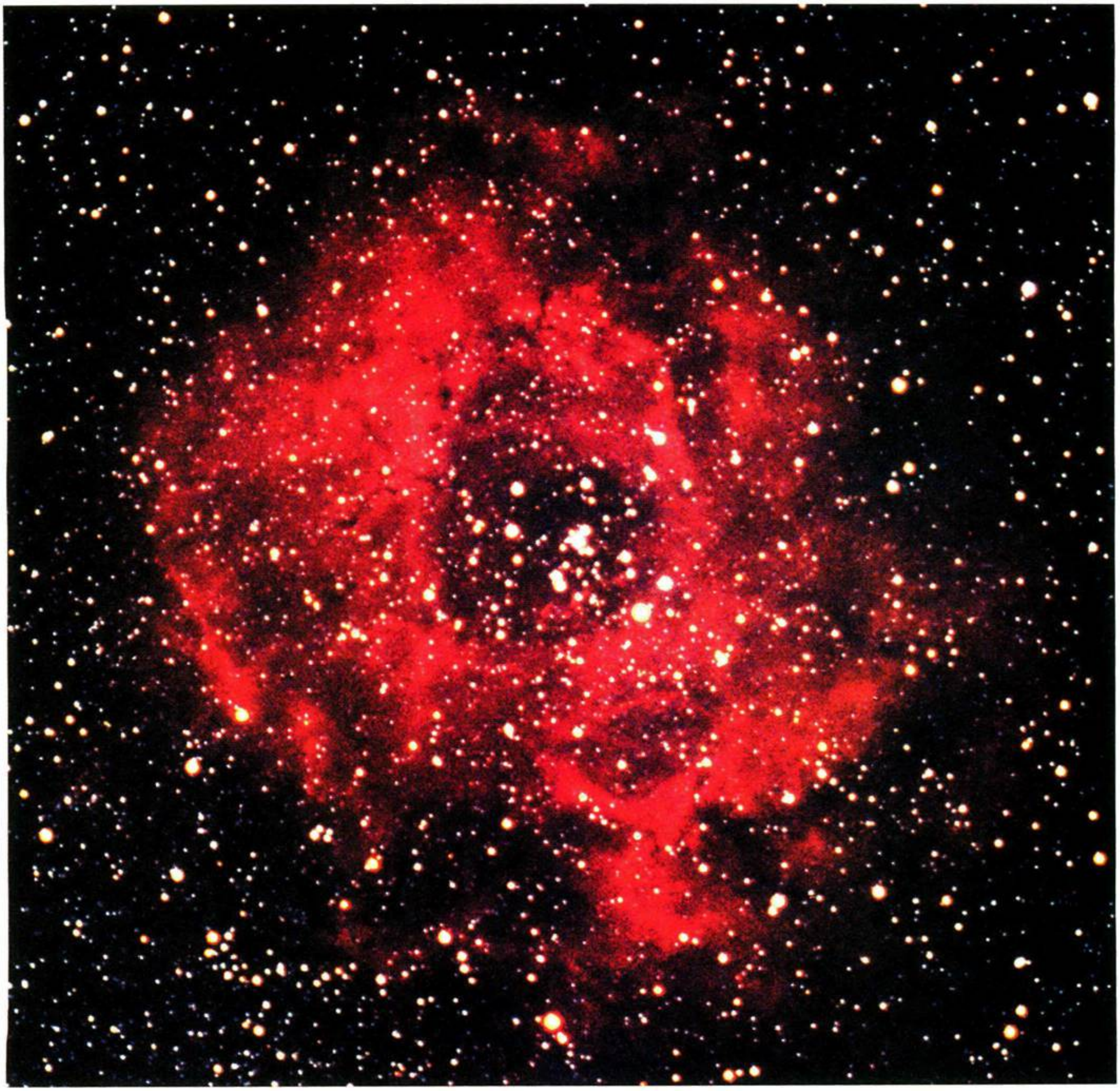
Ouellet currently holds the position of President of the Royal Astronomical Society of Canada, Quebec Centre. He and other club members pub-

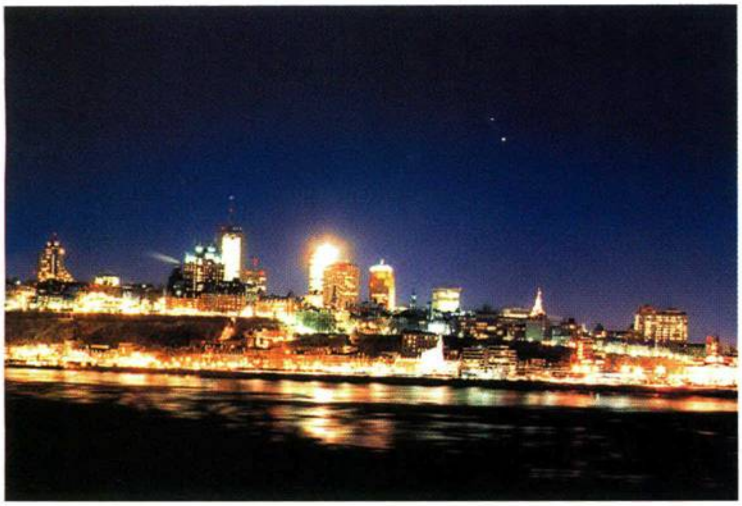




Top: A Geminid meteor cuts through Orion above the Orion Nebula (M42) and the Horsehead Nebula (B33). (Photo by Jay Ouellet and J. F. Dion; 28mm lens at f/4, Kodak PJM 640 film, 20-minute exposure)

Bottom: A closeup on M42 (the Orion Nebula) and NGC 1973–5–7. (5-inch f/6 refractor, Kodak Pro 400 film, 45-minute exposure).





Above: The Rosette Nebula (NGC 2237–9), a glowing gas region surrounding a 5th-magnitude star cluster in Monoceros, was photographed in –22° F weather. Setting up the telescope on a snowbank, calibration, and capturing the photograph took a total of about four hours. (5-inch refractor at f/4.5, Kodak Pro 400 film, 20-minute exposure)

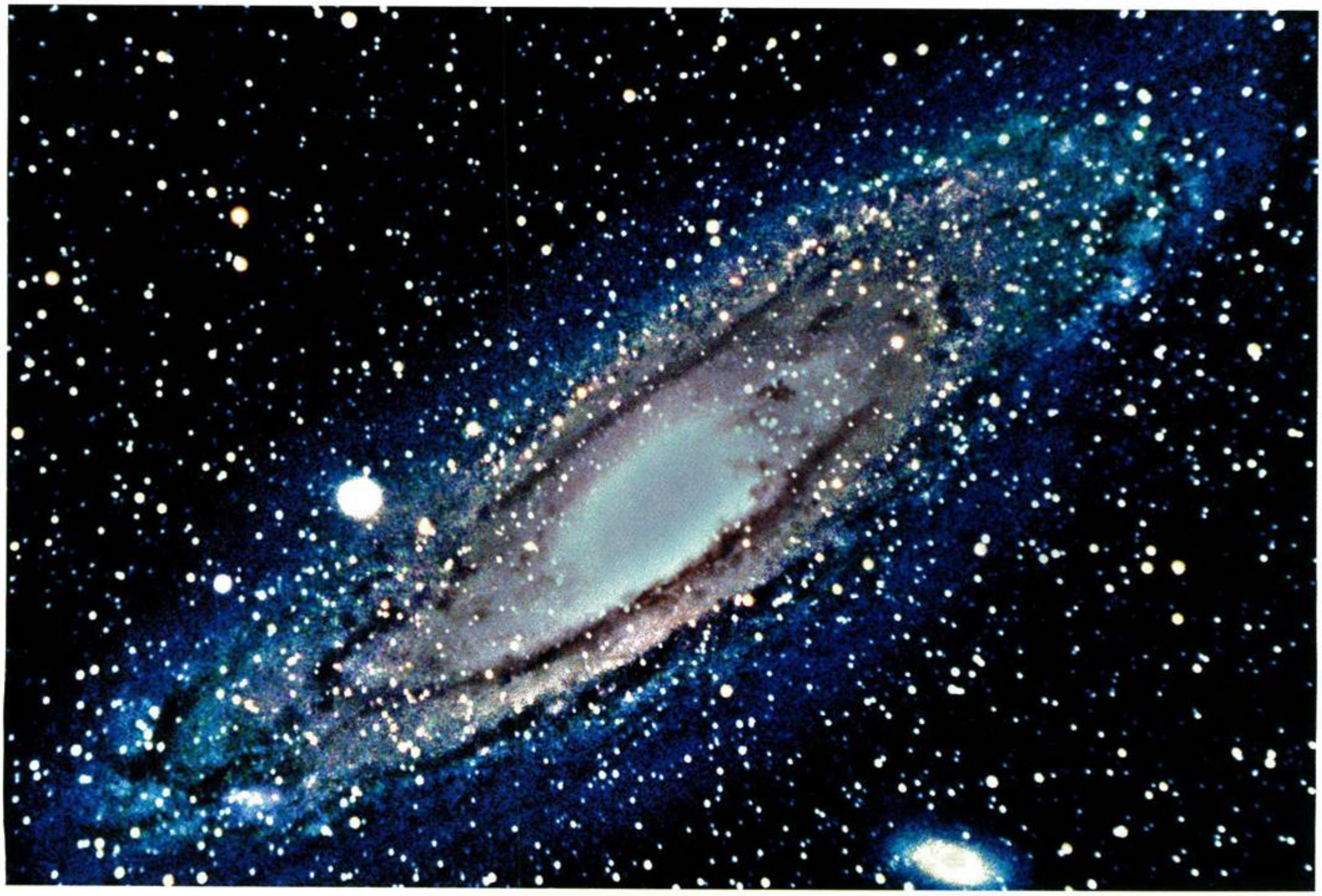
Left: Ouellet stuck the legs of his tripod into 2 feet of snow to stabilize the camera from blustery high winds, which produced a wind chill factor that night of –31° F. The planetary conjunction is of Jupiter and Venus over Quebec City's skyline on February 22, 1999. (28mm lens at f/4, Kodak PPF film, 20-second exposure) lish a color magazine for their club and regularly make guest appearances on television to talk about celestial events.

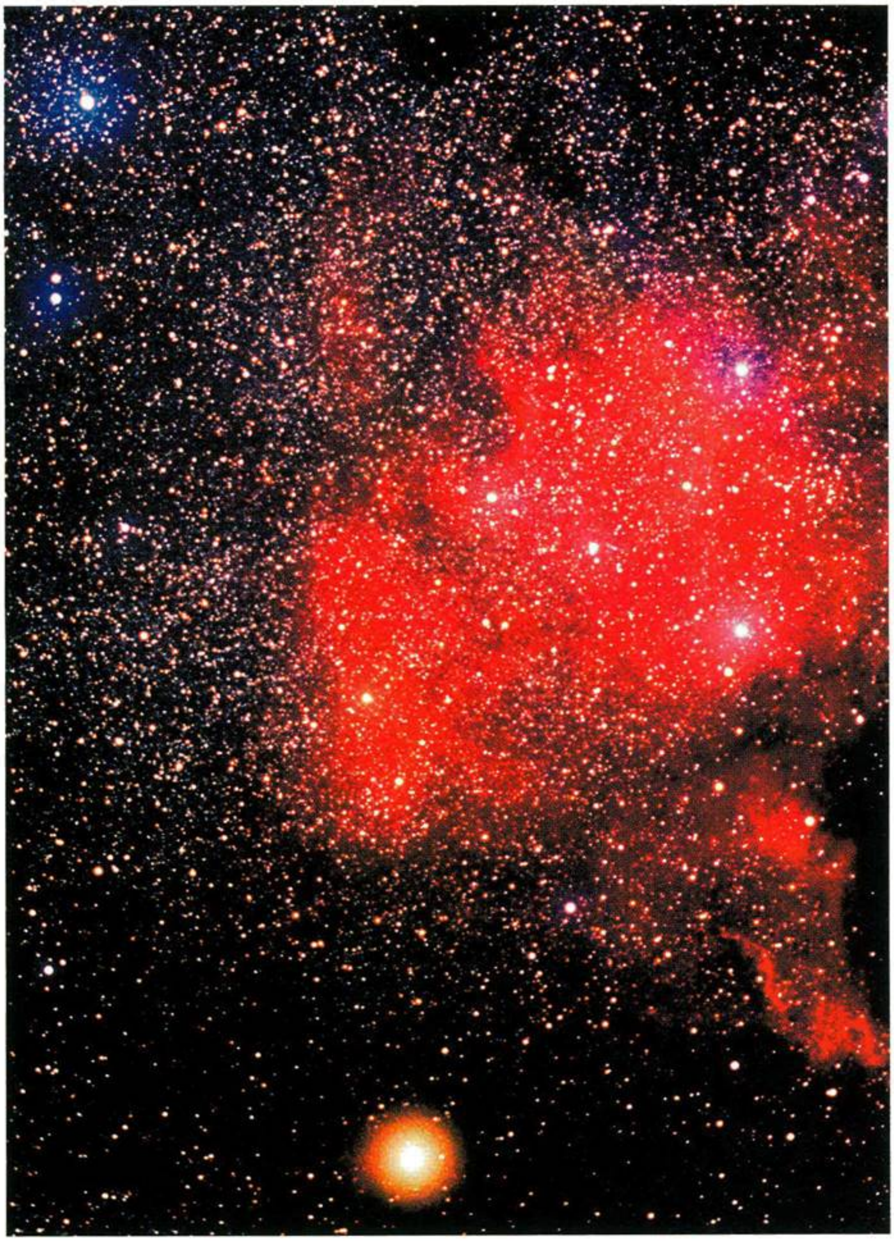
Because of the glow from Quebec City, Ouellet drives out into the countryside in search of unpolluted skies. He hopes to have an observatory soon, but meanwhile in wintertime he sets up his telescope on a founda-

Right: The northern lights erupt. (28mm lens at f/4, Kodak PJM 640 film, 20-second exposure taken August 14, 1998)

Below: The Andromeda Galaxy (M31) is the closest large spiral to the Milky Way. (5-inch f/6 refractor, Kodak PJM 640 film, composite of 55-minute and 40-minute exposures)

Opposite Page: A partial solar eclipse meets a total lunar eclipse. (Lunar eclipse: 5-inch refractor at f/12, Fuji NPH film, 15-second exposure taken September 16, 1996. Solar eclipse: 3.5-inch refractor at f/4.9, Fuji Superia 200 film, ¼-second exposure taken August 11, 1999)



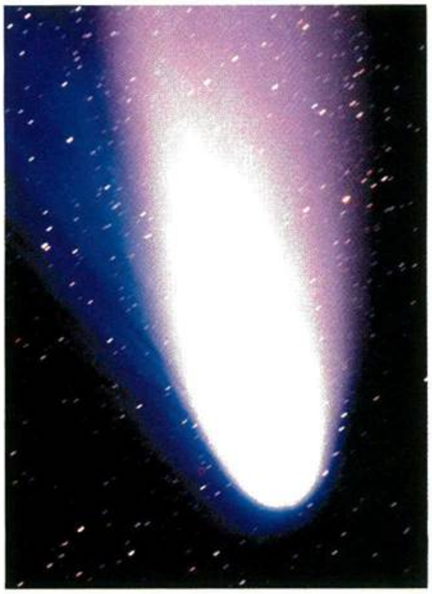


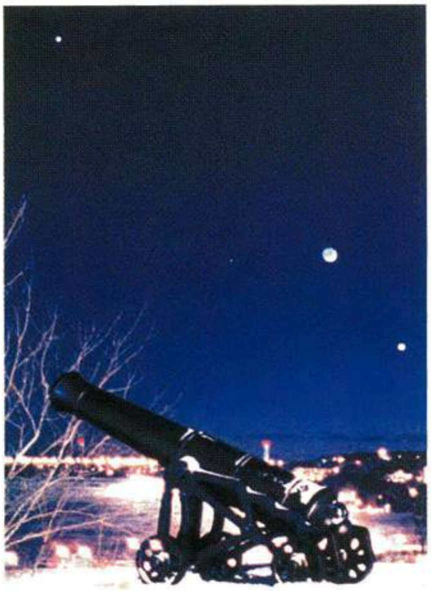
tion of hardened snow between the drifting banks to support its hefty bulk from sinking and to shield it from wind and light. When you add up the drive time, set up time, and observing/photography time, Ouellet chalks up seven hours out in the elements.

Ouellet puts himself through a lot in order to take a single astrophoto. One April, he spent a freezing night on a mountaintop after the alternator broke down in a car he had borrowed. He was an hour and a half from civilization in windy, 20° F weather. He spent the time that he was stranded walking back and forth on the mountainside road, trying to keep his circulation going and in hopes of spotting a car. Finally, at 6 A.M., a patrol car picked him up wandering aimlessly down a desolate country road. They called a tow truck, and two hours and a large towing bill later, he was safely home. All this for a picture. But Ouellet says, "It was worth it!"

Over the years, Ouellet has observed with a secondhand 3-inch refractor, an 8-inch SCT, and a 3-inch Maksutov-Cassegrain. Currently, he takes most of his pictures with a 5-inch apochromatic refractor.

There are advantages and disadvantages to being so far north. Even at −13° F, humidity plagues his operations. At times, his mount is white-coated from frost. Yet, aurorae are abundant and colorful, and not just at solar maximum. What has Ouellet learned from his many winter astrophotography adventures? "Never borrow a friend's car to take a photo. And bring warmer clothes!"





Opposite page: A full moon lights the night. (5-inch refractor at f/12, Agfa Pro 100 film, 1/125-second exposure taken April 18, 2000)

Above: The North America Nebula (NGC 7000) was taken in 85 percent humidity, causing condensation to form on the lens and some of Cygnus's stars to be cocooned in blue and yellow halos. (5-inch refractor at f/4.5, Kodak Pro 400 film, 50-minute exposure)

Far left: Hale-Bopp flies past Earth. (5-inch f/6 refractor, Kodak PJM 640 film, 15-minute exposure taken March 9, 1997)

Left: Jupiter, Mars, the moon, and Venus loom over Parc St. Michel and the St. Lawrence River in Quebec City. (28mm lens at f/4, Kodak PPF film, 20-second exposure taken December 31, 1999)

m-M=5log(d)-5
360° ≡ 2 × π × 3960 miles
F= GMm/r 2
CD = ∠COD = λA − λB.
AB = CD cos BD.
m-M=5log(d)-5
360° ≡ 2 × π × 3960 miles
AB = CD cos BD.
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Astronomy Careers Beckon

It takes more than a knowledge of the night sky to work in astronomy.

by Marcia Bartusiak

Ironically, childhood experience as a backyard observer — although valuable — is not a requirement in becoming an astronomer in the 21st century. At Harvard University, which has one of the top astronomy programs in the country, only a fraction of the graduate students were dedicated telescope users as youths. Advanced knowledge in mathematics, physics, and computer skills prove more important for future astronomers than a practical background in skywatching.

"That was one of my biggest surprises entering graduate school," says Scott Ransom, now in his third year at Harvard. "The majority of astronomers don't have a clue where the constellations are located in the sky," says Ransom. They don't have to. Modern astronomers instead plug in computer coordinates to find specific celestial locations.

Mike Waraksa

Janice Lee | Going Back to Astronomy

Janice Lee's eighth-grade yearbook predicted that she would become an astrophysicist. "I didn't think of being an observer because I grew up in New York City where you can't see the sky," she says with a laugh.

Lori Stiles/University of Arizona

In college, other interests sidetracked her. She majored in mathematics at Cornell University and worked on educational policy in Washington, D.C. After obtaining a master's degree in education and teaching physics for a year at a Long Island high school, she decided to return to her first career choice. Lee, 26, obtained a master's degree in astronomy at Wesleyan University in Middletown, Connecticut, and from there moved into the astronomy Ph.D. program at the University of Arizona.

At a recent conference, Lee was dismayed to hear a noted theorist refer to observers as "the unskilled workers of the night shift." Lee hopes to use her background in mathematics to help bridge the chasm between theory and observation by doing a bit of both. Her current project involves looking at the spatial distribution of low-surface-brightness galaxies to see if the overall mass of the universe is distributed differently from its light. "We can see chains of lights when looking down upon the dark Earth," she says, "but that doesn't necessarily trace where all the people are."

There may be lots of dim, dark galaxies dispersed more loosely than the bright galaxies, some of which appear to congregate to form a spongy texture through the universe.

Lee wants her late decision to enter astronomy to serve as an example to others. "You don't have to follow a rigid formula in your career," she says. "College graduates who decide astronomy might be interesting to pursue can go back." — *M.B.*

Longtime stargazers who plan to pursue astronomy as a course of study are often surprised at the scientific rigor required for the field. Determining how a star or galaxy forms, for example, requires a firm understanding of gravitational forces and hydrodynamics. "Astronomy is physics," stresses Valentin Ivanov, a graduate student at the University of Arizona. "But I also like to think of myself as a craftsman. Astronomy is more hands-on and practical. It's a state of mind."

A career brochure from the American Astronomical Society (AAS) highly recommends a solid foundation in physics and mathematics. It also stresses that most professional astronomy positions require a doctoral degree. Once a Ph.D. is attained, an astronomer enters an elite troop. Only 0.003 percent of all the Ph.D.'s granted annually in the United States are for astronomy. Overall, North America boasts fewer than seven thousand professional astronomers.

However, thanks to the development of new space telescopes and the construction of next-generation large optical telescopes constructed around the world, opportunities in astronomy have increased over the last 10 years or so. In fact, the number of 6.5-meter and larger telescopes built (or being built) over the last decade exceeds that constructed over the last half century. (See "High-Tech Twin Towers" October 2000.) Launching of the Hubble Space Telescope, the Chandra X-Ray Observatory, and SOHO, as well as the many planetary fly-bys, also provide vast new vistas to analyze.

At the start of the 1990s, the United States granted about 85 Ph.D.'s in astronomy annually. Ten years later that number averages 125, a 40 percent increase (although it seems to be leveling off). While the current spurt in new telescope construction makes it appear that prospects are booming, veterans urge caution. Many new positions are based on "soft money" — provisional grants that could evaporate with a downturn in the economy.

Another factor that keeps astronomy jobs scarce is that often, when one new instrument comes on line, an older one closes down, thus keeping employment levels fixed. The

National Radio Astronomy Observatory, for example, is now participating in an international partnership to develop a large millimeter array in northern Chile. As a result, an older antenna — a 12-meter dish on Kitt Peak in southern Arizona — is being mothballed.

According to the American Institute of Physics (AIP), nearly all the new Ph.D.'s in astronomy secure some form of employment in the field at first, but usually not as assistant professors, which was the case about 40 years ago. Today, about two-thirds move into postdoctoral positions that last two or three years. Others become researchers under short-term grants. Only a tiny fraction are lucky enough to immediately obtain a tenure-track slot on a university faculty or a permanent position at a government institute involved in astronomical research.

What happens to this new pool of researchers later, though, can be shaky. By some estimates, only one-fourth to one-half go on to make astronomy their life's work. Those who are shut out gradually move into other arenas, particularly in private industry where the focus shifts from astronomy to engineering or computer software development. Other astronomy graduates end up working in planetariums, science museums, or public information.

"There is a small turnover of positions each year and, therefore, strong competition for positions," cautions the AAS. "Only those with a quality education, ability, and passion for the subject are likely to find a permanent position." For many, astronomy is a field that's more of a calling than a career, and passion for the subject becomes the engine that powers it. Money is certainly not the motivator.

Chris Gottbrath | Cosmic Simulations

"I like to build toy universes inside my computer and smash things together," says Chris Gottbrath, a third-year graduate student at the University of Arizona. He's hoping that this fascination with numerical simulations of the cosmos will eventually lead to a teaching position at a smaller college, where, although access to big telescopes may be difficult to obtain, he can continue his computer-modeling studies.

Lori Stiles/University of Arizona

Gottbrath's thesis involves calculating how pre-galactic building blocks in the early universe merged and evolved into ellipticals and grand-spiral galaxies. In order to facilitate this research, he is setting up a special cluster of parallel-processing computers to handle the immense number crunching required for such a simulation.

For Gottbrath, 26, a valuable asset for an astronomer is having "a physical sense of what is reasonable and what is not." He also believes it's wise not to specialize too much so that you don't miss other career opportunities that may arise. "For instance, if you work on galaxies, you can't afford to ignore stellar astronomy," he says, "since star formation has an effect on galaxy formation. You have to keep up with a variety of papers and concepts."

Unlike some of his colleagues at Arizona, Gottbrath didn't initially choose astronomy as a career. "Astronomy was a cool science, but music was also a draw," he says. While a trombone player in his high school band in northern Indiana, Gottbrath considered becoming a band director. But a summer job at the Kitt Peak National Observatory in Arizona changed his mind.

That's where he was in 1994 when the 20-plus fragments of Comet Shoemaker-Levy slammed into Jupiter. The big telescopes initially had their domes closed, due to the threat of rain. Gottbrath, though, found a small 8-inch telescope tucked away in one of the observatories and quickly set it up outside. He was the first person at Kitt Peak to see the dark impact spots. "It was a unique moment," he recalls. "It came closest to my childhood fantasy of what being an astronomer would be like." — *M.B.*

Initial salaries start around $35,000 and currently rise to an average of $70,000 for a senior astronomer. With their technical skills, astronomers could easily earn more in the corporate world. Nearly all the respondents to an AIP survey indicated that they chose astronomy because of their fondness for it, not because of financial opportunities. But there are perks. In his fourth year in the graduate program at Harvard, Saurahb Jha has already traveled to Chile, Hawaii, and Australia in connection with his research.

About two-thirds of the students entering graduate programs acknowledged in the AIP survey that they aspired to an academic career — a professorship at a college or university. But after a few years in school, they become very aware that the odds are against them. "You don't go into astronomy these days without doing the statistics," says Chris Gottbrath, a graduate student at the University of Arizona.

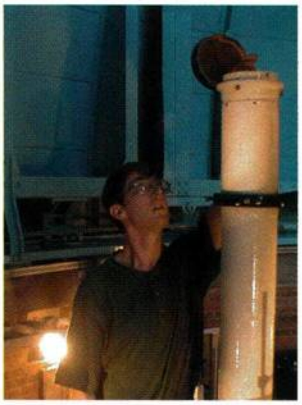
In order to beat the odds, Harvard astronomer Alyssa Goodman advises students to choose their thesis topic carefully. Good astronomers do their homework, stay alert to the questions being asked within the community, and then seek out the tools needed to answer those questions. A thesis that just fills in details of a problem already broadly understood — while valuable and needed — does not necessarily advance a career.

In the end, says Goodman, "it's best to be known for something," whether it's building a new instrument, attacking a problem with several techniques, or emerging as the world authority on a particular issue. For example, at Case-Western Reserve University in Cleveland, Ohio, Ph.D. candidate John Martin is studying the chemistry of high galactic B stars, a less sexy topic than extragalactic astronomy, the most competitive arena in the field. "But it gives you a chance to stand out when applying for a job," he notes.

New astronomers also benefit by becoming good communicators. While a tiny fraction of astronomers succeed solely on the sheer brilliance displayed in their publications, it's a rare achievement. The majority must learn to network among their colleagues and at conferences. "Jobs are often

John Martin | Speaking "Computerese"

John Martin's family credits his interest in space to the many hours his father spent calming him down as an infant while watching *Star Trek* reruns. Now Martin has the unique distinction of being the lone graduate student at Case-Western Reserve University in Cleveland, Ohio — home of the smallest astronomy department in the United States to offer a Ph.D. Martin is currently finishing up his third year of the program.



John Martin

His first exposure to astronomy occurred during his teen years. In a summer job at the U.S. Naval Observatory in Washington, D.C., he worked on cataloging astrometric stellar positions. Later, as an undergraduate at the University of Virginia, he got involved in parallax measurements using photographic plates. "My advisor spent weeks gathering the pre-CCD-era plates from the East Coast," he recalls.

Earlier work with one of the three full-time professors at Case-Western led to Martin's Ph.D. research. The research involves using the 82-inch telescope at McDonald Observatory in Austin, Texas, to study the chemistry of some unusual stars outside the plane of the Milky Way. These objects look like young, massive B stars but could be older stars in a later stage of stellar evolution. The spectra Martin gathers at the telescope may tell the tale.

The one thing Martin has learned as a Ph.D. candidate, he says, is the importance of networking. "You have to build up contacts," he notes. Martin was also surprised by the amount of time he spends on the computer. "Fortunately, I have a knack for speaking 'computerese,' " he says. He stays proficient with telescopes by running public nights at the university's campus observatory.

Upon finishing his thesis during the next two years, Martin expects to move through a series of postdoc studies while searching for a more permanent position in academia. — *M.B.*

Pauline Barmby | The Dual-Career Dilemma

Canadian Pauline Barmby thought she would go into either physics or engineering. "My father thought I should be more practical," she says. So she took a summer job at a civil engineering firm and learned about sewers and dams. But her interests switched to astronomy when she began to consider becoming an astronaut.

Now in her fifth year at Harvard, Barmby, 27, hopes to obtain her doctoral degree by the end of 2000. She has been using the 48-inch telescope on Mount Hopkins in Arizona, as well as the 3-meter telescope at the Lick Observatory in California, to study globular clusters in other galaxies. She is particularly interested in the clusters surrounding the Andromeda Galaxy.

Barmby observes those objects with a variety of techniques, including optical photometry, spectroscopy, and in the near infrared. Some of these globular clusters are rich in such elements as carbon, oxygen, and nitrogen, what are known as "metals." Other globular clusters are metal poor. She hopes to determine why this discrepancy occurs, which may shed some light on how a galaxy forms.

Upon finishing her dissertation, Barmby faces competition for a postdoctoral position. She also has the infamous dual-career problem: Her husband is a medical physicist. She has narrowed her job search to cities where both careers can thrive, perhaps Boston, San Francisco, Washington, D.C., or Seattle. — *M.B.*

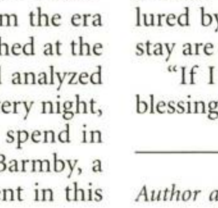
Charles McKenzie

decided by the talks students give as they enter the professional world," says Ransom. "I would never have guessed that when I was in high school." Astronomy is not for the people who need their hands held, adds Ransom's classmate Jha. "You learn from talking with other people, such as fellow graduate students and postdocs. It's up to you to pick up the skills you need," he says.

Tinkerers have an edge. "People who can build instruments can have their pick of jobs," says Goodman. At the University of Arizona, for example, graduate student Joannah Hinz is helping build a near-infrared camera specifically to increase her experience in hardware. She will be using it to search for brown dwarfs.

And, more and more, it's becoming necessary to be a computer jock. Astronomers long ago moved away from the era of bulky photographic plates and chilly nights perched at the prime focus. Almost all data are now gathered and analyzed with computers. "I knew I wouldn't be observing every night, but I didn't realize all the monotonous time I'd spend in front a computer analyzing data," notes Pauline Barmby, a Ph.D. candidate at Harvard. "You have to be patient in this field. There is no instant gratification. The 'Eureka!' moments are rare."

A new trend at many university departments is to hire a new Ph.D. in astronomy to administer the department's computers and then allow for part-time observational opportunities as well. For instance, astronomical surveys, such as the Sloan Digital Sky Survey, which is now gathering immense stores of data by imaging the sky beyond the Milky Way, present additional points of entry for beginning astronomers. An upcoming specialty may well be the astronomer/computer scientist, who must devise the means to maneuver through extensive data bases in order to answer certain questions about the universe.



The upside to this trend is that it allows astronomers to easily shift careers in times of tight job markets. And astronomers with advanced computer experience can apply their skills in a number of arenas. Indeed, many are already leaving graduate school, lured by the potential riches of the Internet. But those who stay are carried by their zeal.

"If I can only do it for six years, I'll still consider it a blessing," says Gottbrath. "I will have lived my dream."

Author and science writer Marcia Bartusiak is a member of Astronomy's *editorial advisory board. Her article "Catch a Gravity Wave," appeared in the October 2000* Astronomy. *Marcia's latest book is* Einstein's Unfinished Symphony. *Find it in bookstores or order it directly through http://www.jhpress.org.*

Good Morning, Gentlemen

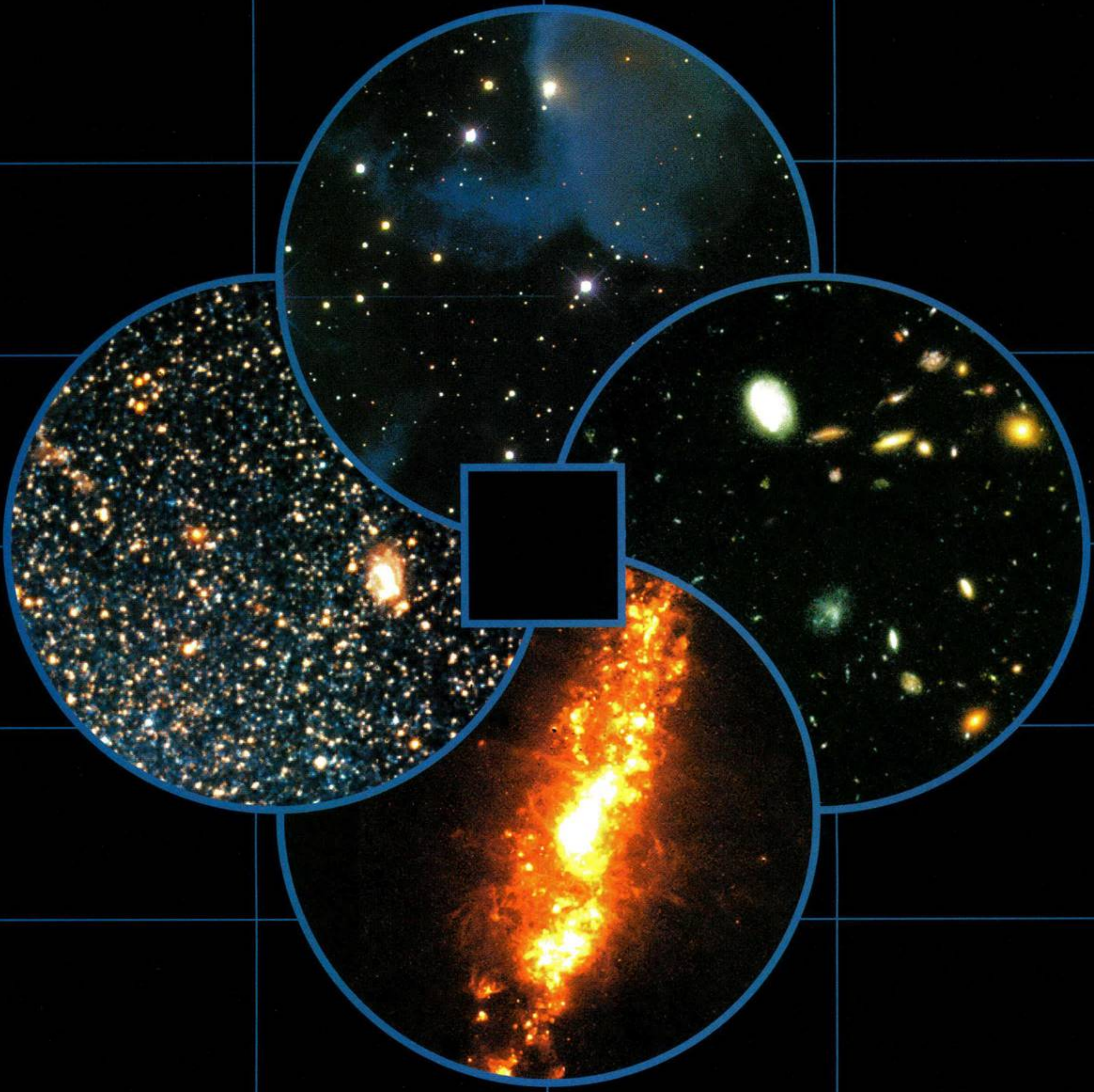
and Meg

Women fight to get a fair shake in astronomy.

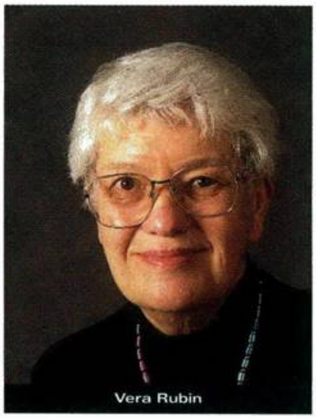
by Ann Finkbeiner

Female astronomers are now and always have been underrepresented, underpaid, and undervalued. This isn't the 1880s, when Wellesley College astronomy professor Sarah Whiting was asked by a colleague, "If all the ladies should know so much about spectroscopes and cathode rays, who will attend to the buttons and breakfasts?" This is now, a century later, when women are half of the labor force and a fifth of all scientists and engineers but still under a tenth of all astronomers. Vera Rubin at the Carnegie Institution is nearing the end of her distinguished career and is, as she says, "getting fed up. . . . What's wrong with this story is that nothing's changing, or it's changing so slowly. For 20 years, I've been optimistic that things are getting better and better. But 20 years later, it's still 6 percent, and sure, that's better than 2 percent. But four percentage points in 50 years isn't saying much." And despite endless analyses, no one quite knows why.

Clockwise from top: A dust nebula is revealed by the Sloan Digital Sky Survey. The Hubble Deep Field harbors countless galaxies. NGC 55 glows with the fires of star formation. A star field in M31 hides a dubious dwarf-galaxy companion. Clockwise from top: Knapp (Princeton) and SDSS. HDF Team (STScI and NASA). CTIO, Ferguson, Wyse, and Gallagher. Wyse, HST (STScI and NASA)



What happens next depends on the woman. "At 16, I wanted to do math and science," says Gillian Knapp of Princeton, "and I thrashed around to see what was the matter with me. Then I just said, 'So there's something the matter with me. So what? I'll just go and do what I want.' " This is now a more interesting story altogether: how women manage to stay in astronomy anyway.



Vera Rubin

Jon Goell

In the first place, things are indeed getting better. Women now win competitive professorships and postdoctoral fellowships, chair national committees, and direct national observatories; the numbers of young female astronomers are at an all-time high. "There has been a huge improvement," says Wendy Freedman of the Carnegie Observatories. But the bottom line is the same as in the bad old days: few women get in and fewer stay. One quarter of graduate students are women, but only 7 percent of tenured full professors are. (Rubin's 6 percent isn't necessarily a contradiction; besides, she says, "it doesn't even matter — it's just pathetically small.") And when women do stay in, their salaries for a given rank are lower; they're unlikely to be on the track for tenure; they don't get promoted as quickly, they are scarce in the higher ranks; their offices are smaller; and their voices are less audible.

The reasons for women's underrepresentation have been the subject of countless surveys, articles, committees, websites, newsletters, and symposia in innumerable departments, journals, professional societies, and agencies. The results of all this brainpower are a little vague. One reason often given is that women aren't encouraged by those whose job it is to encourage young scientists: parents, teachers, advisors. Another reason is that women are bent socially to be cooperative and consensual, to be less self-confident, less self-promoting, less competitive. Another is that women most often marry their colleagues and then face all the tricky balances of a two-career marriage. Analysts now say that women's discouragement comes from no single great obstacle but from years of accumulating small, subtle ones. "Each incident is nothing," says Gillian Knapp, "but together they erode you." The incidents include trivialities such as standard masculine pronouns, being addressed not as Dr. but as Mrs., and "saying something in a meeting and it's ignored," says Stefanie Baum at Space Telescope Science Institute (STScI), "then the guy next to you says the same thing and it's great." Such incidents are incremental, says Megan Urry, also at STScI, "and only after a while do you feel the weight of them."

Lisa Storrie-Lombardi

Charlie Bluehawk

I was raised to be the perfect housewife. My mother's just baffled that I'm an astronomer. The people who can say, "I've wanted this since I was 10" — I'd have killed for that clarity.

— Lisa Storrie-Lombardi

Most simply, women are seen to be different. From the time they were college students, they have heard the equivalent of the words — sometimes kindly meant — with which Urry's graduate classes began: "Good morning, gentlemen and Meg." Occasionally, the words are unkind: Knapp says her undergraduate classes in physics had three women "out of 60 or 70. One professor would harangue about women not belonging here until we burst into tears and then he'd leave. We learned to burst into tears really fast." Sometimes no one says anything particular: During Lisa Storrie-Lombardi's first postdoctoral fellowship, "the department was all men. I was startled that I noticed it. I didn't handle it well — I just didn't feel connected." The point is, such incidents, whether outright illegal or barely noticeable, are evidence to women that they're outsiders.

Wendy Freedman

Raleigh Souther

The other point is such incidents are the universal reactions to someone different. "It's human nature," says Rebecca Bernstein, a postdoctoral fellow at the Carnegie Observatories, "and any change will be a long time coming." Sandra Faber, who was hired at Lick Observatory about when Bernstein was born, agrees: "It's the way it is. So then you say, 'So what?' "

Meg Urry

Laura Miller

I interviewed 15 female astronomers who are now at nine of the country's best astronomical institutions. They range from postdocs to senior faculty. They agree that the basic problems of career-building in a difficult science were the same for men and women, but that women had this extra problem of difference. "You do

Sandra Faber

R.R. Jones

stand out and that can either hurt or help," says Bernstein. "But I don't think being different always helps. There's not an animal on the planet that feels relaxed standing out like a sore thumb."

They disagree, according to their own personalities, on styles of handling the difference. For instance, Anneila Sargent, who is at Caltech and president of the American Astronomical Society, says, "It doesn't hurt to be an engaging person. 'Compromise' is not a dirty word." But Daniela Calzetti at STScI says, "I start the fights. I'm quite aggressive." They do converge, however, on a broad rule for staying in astronomy: define yourself as an astronomer. This rule has several subrules.

1) Fit into a mostly male community. Most of those I interviewed stayed in by paying less attention to the word "male" than to the word "community." After Knapp said that in graduate school she'd learned to cry fast, she added, "But it was a relief, for the first time being around other nerds." And now, she says, her male and female colleagues "are all pretty similar — vain, hard-working, and fortunate, extremely fortunate." Astronomy "needs a passion, an ability, a single-mindedness," says Wendy Freedman, "and that's all true for men and women both." These women aren't trying to change gender: "I don't go into this wanting to be a man," says Anne Kinney, director of the Origins program at NASA. "The goal is to do good work." Rather, they include themselves and their male colleagues in a larger category, the community of astronomers. Such "redefining is not hard where people so love the field," Kinney says. "It's the main coping mechanism." Crystal Martin is at Caltech on a postdoctoral fellowship: "I'm in the community now. It's one I enjoy being a part of."

Fitting into the community, however, also means competing for limited resources. The National Science Foundation funds about one astronomical proposal in four. STScI grants telescope time to one in five. Ten Hubble postdoctoral fellowships receive 140 applicants. In this field, Urry says, "the personality filters screen out the diffident. The aggressive get through." Freedman says she has to "defend my science against people who want me off my own telescope, get me uninvited from meetings, and call me incompetent publicly. Our field is not gentle."

Anneila Sargent

Bob Paz

Everyone I interviewed was conscious of how she handles competition.

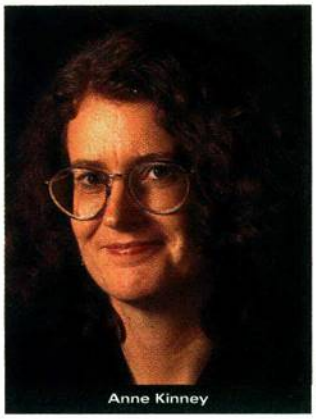
> I was a tomboy and loathed and disdained girls' pursuits. I didn't want to be part of the girls' world. So adolescence was hard, and I was a loner.
>
> — Sandra Faber

Freedman dissociates the scientific from the personal: "In the Hubble constant controversy, I look at my male colleagues jostling around and hurling things at each other and I don't feel singled out at all. It's not because I'm a woman." Rubin avoids the jostling and hurling: "I couldn't take the sociology," she says, and instead picks problems no one else worked on "but results they'd be pleased to have." Rosemary Wyse at Johns Hopkins jostles and hurls: "I was brought up Catholic on the [Protestant] east coast of Scotland, so I am used to asserting my right to be where I want, doing what I want." No one handles competition in any one way, of course. But they all seem to take Sargent's father's motto: "It's a great life if you don't weaken."

Competing requires self-confidence, which also seems to be a prerequisite for fitting into a male community. "What it really takes is a male ego," Bernstein snaps. "When you're trying to compete with the top three percent in your business, you're going to hear 'no,' and you can't go around feeling bad about it," says Lisa Storrie-Lombardi at the SIRTF Science Center at Caltech. They all say they consciously construct confidence. They said time helps. Calzetti has been on tenure-track for several years: "I've built confidence over the years. Now I have an indestructible self-confidence."

Daniela Calzetti

STScI



Anne Kinney

Jon Goell

Experience helps too. Urry says she'd earlier "imagined everyone else was as good as I was or better. Now, after 20 years' experience, I rarely feel that same intimidation." Anne Kinney explains, "When you're from a small town, you stitch together your own world. That builds your self-confidence. Nobody else is going to do it." Faber is blunt: "I've never really failed at something that mattered to me."

2) Be tough as nails. For all their determination to fit in to the community, they don't do so seamlessly. Some handle the resulting isolation or intimidation by seeking out other women;

The One Large Imbalance

When I asked 15 female astronomers what it takes for women to succeed in astronomy, they usually answered, "about what it takes for men to succeed." The added discouragements are cumulative, they said, but tractable. Small disadvantages "make you uncomfortable," said Daniela Calzetti at the Space Telescope Science Institute (STScI), "they don't destroy your career." The one large imbalance they saw in women's situations is in the broad and nebulous area of sex, marriage, and children. Sandra Faber at the Lick Observatory said it flatly: "The careers of women are never going to look like the careers of men."

Nobody would recount for publication the nonconsenting sexual incidents — usually overt propositions — that are inevitable when women and men work together. "This doesn't happen every five minutes," said Anneila Sargent at Caltech, "but it happens to all of us sooner or later." "You need the resilience to ignore or to deal," said Wendy Freedman at the Carnegie Observatories. Everyone who told these anecdotes said they first got uncomfortable and worried, then behaved as though nothing happened and hoped for the best. "Most of it doesn't turn out negatively," said Freedman. What they worry about, of course, is the effect on their careers: "Someone being attracted to you is always an obstacle, especially if they're senior," said Sally Oey at STScI. "You don't want to say, 'screw off,' " said Sargent, "because you might want his good will."

When the attraction is mutual, the next obstacle is what the field calls "the two-body problem" — couples who want geographically neighboring jobs. The two-body problem is worse for women: female scientists tend to marry male scientists, but not the reverse. "My boyfriend is in astronomy, unfortunately," said Lori Lubin at Caltech. The likelihood of finding two good jobs in the same area is small, but all nine of the married women I interviewed had done it anyway. They were split fairly evenly among those who followed their husbands to jobs, those whose husbands followed them, and those who did a little of both. Most had periods of living separately, usually a year or so, but Calzetti and her husband have been married eight years and "lived together about four," she said. "Neither of us wanted to give up our careers." Rosemary Wyse at Johns Hopkins has been in a bicoastal relationship for ten years: "It doesn't seem unstable. We'd prefer to live together, but I'd also prefer to be a multimillionaire."

Kinney is unmarried, "and it's not unrelated," she said. "It's a luxury to be in this field, and the two-body problem is one of the prices. That's just life."

Children raise the price higher. Some women — especially older ones — accepted the greater share of parental responsibility, meaning that their hours were longer and professional contacts lower: "I always got home by 5 P.M. and came back at 8 P.M. when the kids were in bed," said Sargent. "What I missed was having time to shoot the breeze." Other women are what Megan Urry at STScI calls "coparents." "When the kids went into school," said Gillian Knapp at Princeton, "my husband and I just switched off getting home. It's like Wendy said once, we're a two-person one-parent family." "It's extraordinarily, pleasurably busy," says Wendy herself, but even so, "you have to be extremely scheduled." All these women become, as Faber says, "ruthless about minutes." "When I was younger," she explains, "I had less time than my male colleagues. I was absolutely ruthless in saying only two things I would do. If I'd picked three things, I'd have given up astronomy."

None of these women was complaining. On the contrary, they expressed deep, real gratitude toward their husbands — for taking up the slack during observations or deadlines or travel, and for general moral support. When I asked Vera Rubin at the Carnegie Institution how women managed, she said, "Number one is to have a supportive husband." Their gratitude might also come from comparing their own husbands to other men they knew, though only Knapp was explicit about it: "If your husband doesn't cooperate, you have a stark choice. The wrong man is a disaster."

They all noticed, as Lisa Storrie-Lombardi at Caltech said, "women who want to have families have a harder time than men who want to have families." One graduate advisor, she said, "would say that from now on, he'd accept only graduate students with children because they were used to staying up all night and could multitask. Nobody could believe I catch up on sleep during observing." —*A.F.*

Crystal Martin

Caltech

some don't. They all seem to have a central resource, a core of determinedness. Rubin recites a fast list of discouragements: Her high school physics teacher told her to stay away from science, and Princeton University answered her request for a catalog with, "Inasmuch as we do not accept women, we will not send you a catalog." And then she says, "The point of all these stories is, I desperately wanted it. They just didn't understand and I didn't care if they did."

Freedman says that as a student, one of her male classmates told her, " 'Women belong in the kitchen and in the bedroom,' and I thought, 'There are jerks in this world.' And at the end of the course, he had the D and I had the A." Storrie-Lombardi's colleagues noticed she was older than other postdocs and told her, " 'If you haven't done your work by age 35, you're not going to do it.' And I say, 'Well, stuff it. I didn't figure it out until I was 33.' "

Along with universal determination is universal hard work. "It takes luck, hard work, complete concentration," says Faber. "My strategy throughout life is, how few minutes can I give to this, and still feel satisfied?" She says she works "about 70 hours a week, week in and week out," and Urry says 40 hours is a slow week. Bernstein says, "most of my colleagues work a hard six days, if not seven days a week, and 12 hours a day." When "there's something big," Freedman says, "I work from 3 A.M. to 7 A.M. The kids get up at 7 A.M.; we get them out the door. Come home from work at 6 P.M. Go to bed 10ish. Weekends, 3 A.M. to 11; it doesn't impact the kids. My sister told me, 'you're nuts, you better slow down,' and I took her advice for a few days. But I enjoy working hard. Those work hours sound horrendous, but they're not. If you love it, it's not hard."

3) And that's the last subrule: love astronomy. For some, the love started young. When I asked Calzetti when she knew she wanted to be an astronomer, she said, "since ever." Knapp, as a child, had asthma: "The nights I couldn't breathe, I just spent watching the stars go by and thinking about them." Rubin said much the same: "At age 10 or 12, I had a bed under a north-facing window and watched the stars, and soon I would rather watch the stars than sleep." Sally Oey, a postdoc at STScI, had "a two- or three-inch refractor. The first time I looked at Saturn — the light from it lands on your eye so it's really there — I was just so excited. Something clicks when you see something elegant." Freedman recalled, "For me, I came into this field because I loved it. I can't believe I'm paid to do this. When it's time to go home, I can't believe the whole day has gone by."

Rosemary Wyse

Jay Van Rensselaer

Variants on this last are nearly universal. "It's really a privilege to be paid to do this," says Storrie-Lombardi. "Being paid to do this is not normal." Sargent says, "I feel astonishingly successful. I can't believe I'm here." Calzetti's English is her second language: "I think my job is a call more than it is a job. In fact, I don't think it's a job at all. It's a liberation, a joy."

Sally Oey

STScI

Rubin must be the prototype of how women manage to stay in astronomy. "Nothing discouraged me," she said. "It's an incredible universe we're in and how could you do anything but try and learn about it?" About 15 minutes into the interview, Rubin said she was bored telling me her life story, she'd rather talk about an elegant observation she'd made about spiral galaxies that behave like ellipticals. "That's what I like to do," she said, "go off and find a nice result. Just sit here and look at galaxies and nobody bothers me and I can get a result no one expected. I just love it. I can't imagine having more fun. The fact is, we really don't know what the universe is doing. We might die thinking we know some things that turn out to be wrong. And that's okay."

Lori Lubin

Lori Lubin

Why is that okay?

"Because then the children can have the fun."

So what does it take to stay in astronomy?

Storrie-Lombardi: "Fortitude."

Oey: "A thick skin."

Faber: "Think clearly about what you want and don't make the list long."

Wyse: "Let's take it as a given that you love your work and are good at it."

Knapp: "Lack of imagination, pure and simple. I can't imagine not doing it." ■

Ann Finkbeiner is a freelance science writer who teaches at the Writing Center at Johns Hopkins University. Her most recent book is After the Death of a Child.

I don't think women are truly unflappable, and neither are men. You just deal with those upsetting things as best you can.

— Lori Lubin

PUTTING STARS

IN THEIR PLACE

The creation of the Hertzsprung-Russell diagram was a landmark advance in our understanding of the stars.

by James Trefil

Imagine you are being given an important assignment by a taskmaster with a strange sense of humor. Your job is to study a forest, but you can only work according to a rather bizarre set of rules. For five minutes you can take all the pictures you want. You can photograph thousands of square miles of trees in any part of the spectrum. You can look north, east, south, and west. But you are not allowed to touch a tree or leaf, and after your five minutes are up, you can collect no further data.

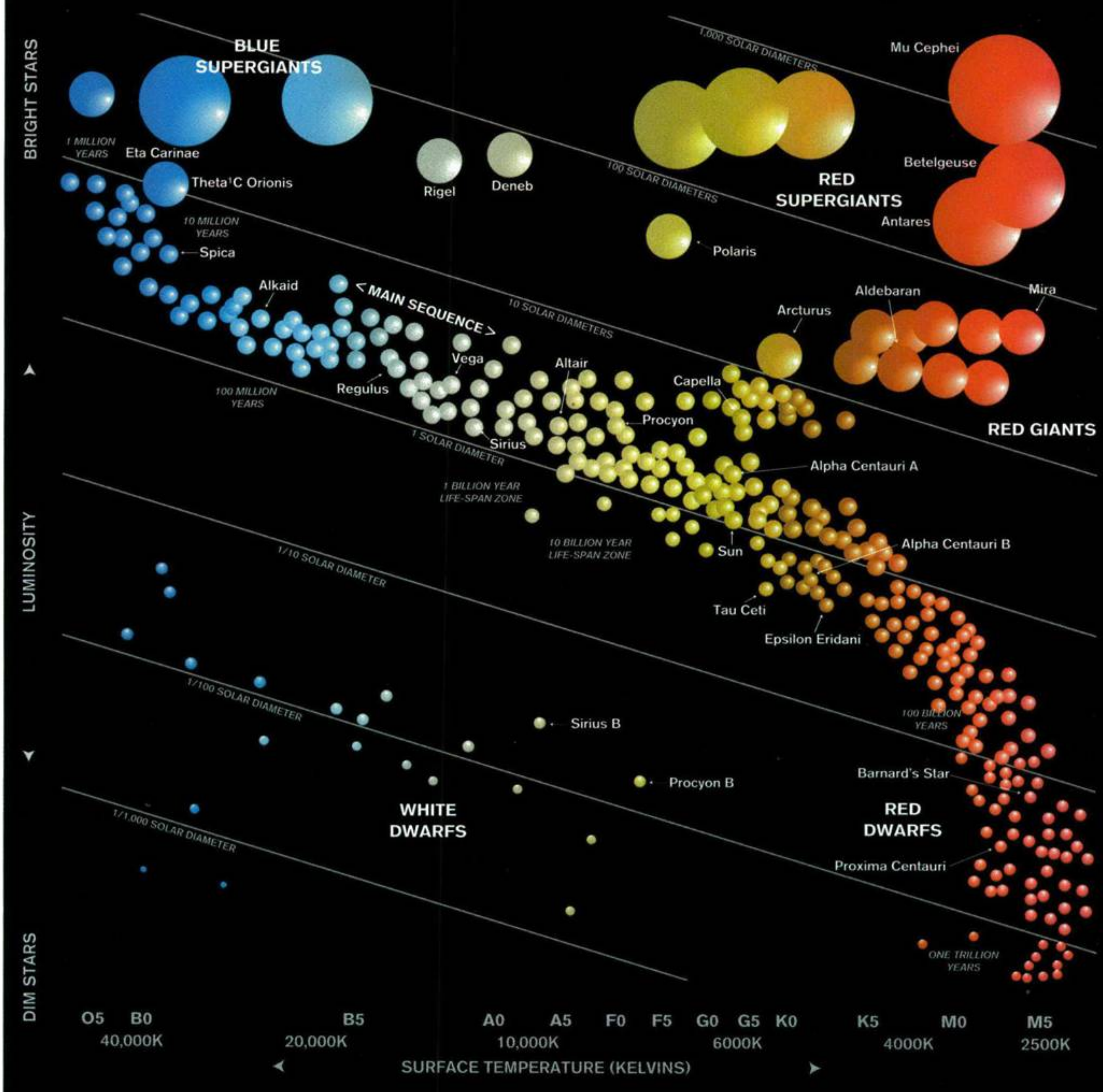
Even with these constraints, you could do a pretty good job of figuring out how the forest worked or reconstructing the life cycle of a pine tree. You would see seedlings popping up out of the forest floor, mature trees, and dead logs. By seeing trees in all stages of growth and death, you could ascertain their life cycles. You would also realize that there are many different kinds of trees — oak, pine, and spruce — and understand how their life cycles differed from one another. It wouldn't be easy. You might find yourself engaged in debates with other scientists about whether oaks and pines were separate species or different stages in the life of a single tree. But in the end, you probably would succeed in your task.

While no one would ever try to study a forest this way, astronomers are forced to study stars under a similar set of rules. The reason is simple: human lifetimes are measured in decades, science in centuries, but most stars live for

Henry Norris Russell and Ejnar Hertzsprung studied stellar spectra to develop the HR Diagram.

Photos of Russell and Hertzsprung: Astronomical Society of the Pacific / Background image: The Observatory of the University of Michigan

THE HR DIAGRAM



The Hertzsprung-Russell diagram was the key that unlocked the secrets of stellar evolution. Stars are positioned on the HR diagram according to their luminosity (vertical axis) and surface temperature (horizontal axis).

Stars fall into three main groups. Most stars, including the sun, fall on the main sequence, the band running from upper left (hot and bright) to lower right (cool and dim). Main sequence stars generate most of their energy by fusing hydrogen into helium. A star's position on the main sequence is determined by its initial mass. Massive stars shine brightly but die young.

When stars near the ends of their lives, they swell enormously in size to become red giants and supergiants, situated at the upper right. The most massive stars explode as supernovae, while stars with less than about 10 solar masses form planetary nebulae. The inert cores of low-mass stars contract under gravity to become white dwarfs — the dim, hot stars at the lower left.

Harvard astronomers worked out the spectral sequence OBAFGKM, which is based on temperature, at the end of the 1800s. The star sizes in this illustration are not shown to scale. Red giants are thousands of times larger than red dwarfs.

Sue Biebuyck

billions of years. Compared to the lifetimes of stars, the entire record of systematic observations of the heavens is little more than the blink of an eye. Like the would-be forester, astronomers are armed only with snapshots of a single moment in the life of the universe.

But even with these restrictions, astronomers have pieced together the life cycles of stars. One of the crucial steps on this road to understanding was the development of the Hertzsprung-Russell diagram.

First Steps

Astronomers at the end of the 1800s knew that stars had a finite lifetime, but they had no idea where stars' energy came from. They could identify some of the chemical elements in stars by looking at their spectra. They could even measure the distances to nearby stars.

But they were confronted with a problem — there are many types of stars in the sky. Some stars are white-hot, others burn a cool red. Some are much bigger than the sun, others are much smaller. Like all scientists confronting complex natural phenomena, their first job was to try to bring some order to the part of the universe they were observing.

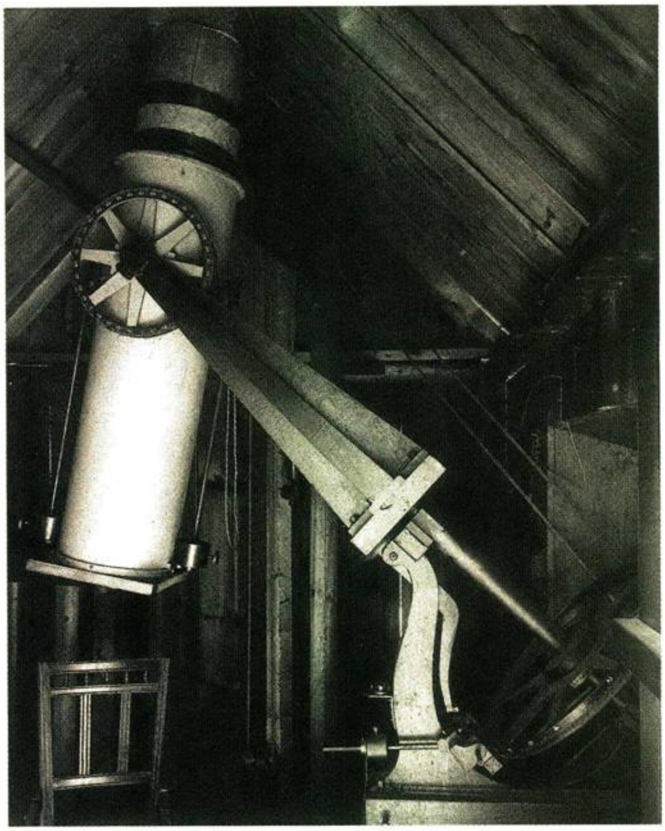
When scientists are confronted with a collection of objects, they try to find similarities that allow them to define groups and differentiate one group from others. In the 1700s, Swedish biologist Carolus Linnaeus noted that squirrels were more like rabbits than they were like snakes, and that snakes, rabbits, and squirrels were more like one another than they were like palm trees. This led him to our present scheme for classifying living things based on genus and species.

The first person to classify stars was Italian astronomer and Jesuit priest Angelo Secchi. In the 1860s, he set out "to see if the composition of the stars is as varied as the stars are innumerable." Working with spectra of 4,000 stars, he found that they could be categorized into four separate classes. These ranged from bright, white stars with lots of hydrogen to faint, reddish stars with lots of carbon.

Secchi felt (correctly, as it turned out) that these differences arose because his different classes of stars had different temperatures. That isn't too surprising. A piece of metal placed in a flame first glows dull red, then becomes white-hot as its temperature rises. But astronomers knew the differences in stellar spectra could also have arisen because of different chemical compositions. This quandary provided one of the main battlegrounds for the remainder of the 19th century.

On one side stood astronomers who believed that all stars have more or less the same initial chemical composition, but that their spectra change as they go through their life cycles. On the other side were those who argued that different groups of stars were made from different collections of chemicals. Astronomers had little understanding of how atoms emit light and how conditions in a star might affect that emission, so resolving this issue was not a simple matter. In the words of American astronomer Walter Sydney Adams, "We can hardly hope to understand the behavior of matter in distant stars when the mechanism of light given out by a candle flame is still quite unknown to us."

The debate was hampered by other kinds of ignorance as well. For example, astronomers who argued that differences in stars were due to evolutionary processes didn't know just how that evolution might take place. One popular theory held that stars derive energy from heat released as gases contracted under the force of gravity. A star would contract until the center liquefied and could contract no more, at which point the star would start to cool off and die. Each star would pass through a given temperature twice — once in the warming phase, and again during cooling. A given spectrum would appear twice in a star's lifetime, corresponding to the two times it reached a particular temperature.


Harvard astronomers employed the 8-inch Bache refractor to classify stars and assemble the Draper Catalogue. Harvard College Observatory

Determining distance, while possible for nearby stars, took a long time and hadn't been done for many. Similarly, taking stellar spectra required that light from an individual star be isolated, run through a prism, and allowed to strike a photographic plate. A single exposure could take anywhere from minutes to hours, depending on the star's brightness. Again, the process was too laborious to be used in large-scale surveys.

Women Take the Lead

But all this changed in 1886. Harvard College Observatory, under the direction of Edward Pickering, initiated a survey of the spectra of bright stars in the Northern Hemisphere. Called the Draper Catalogue (after Henry Draper, a pioneer of American astronomy), it was assembled using a new technique. Instead of isolating the light from each of the stars in a field to obtain one spectrum per photographic exposure, a prism dispersed the total light from the field. Consequently, photos contained multiple bands, with each band representing the spectrum of one star. Spectra of many stars could finally be taken simultaneously. For the first time, stellar classifiers could work with a large database. "The Americans," retorted one English astronomer, "have always been appreciative of mass production techniques."

Stellar classification has the distinction of being the first major advance in astronomy in which women played a leading role. The first stellar classification work reminiscent of the modern classification scheme was devised by Pickering and his assistant Williamina Fleming. They classified stars alphabetically A through Q based upon the strength of hydrogen lines in the spectrum.

In 1888, Antonia Maury, the niece of Henry Draper and one of the few women in the United States trained in physics and astronomy at the end of the 1800s, entered the picture. Also working at Harvard, she noticed subtle differences in stellar spectra. For example, some stars had wide spectral lines, while others had thin lines. This led her to propose expanding the system into 22 classes, including subdivisions a, b, and c.

After Maury left Harvard due to differences with Pickering, Pickering turned to Annie Jump Cannon. Cannon analyzed the spectra of 1,100 individual stars. Rather than focus solely on hydrogen lines, she rearranged the sequence to represent a smoother progression of spectral features due to the presence of highly ionized elements such as helium, nitrogen, and silicon. Like Maury's before, Cannon's classification system began with O, with the final sequence reading O, B, A, F, G, K, and M. In addition, Cannon's scheme resulted in the ordering of stars according to color, ranging from blue O stars to red M stars.

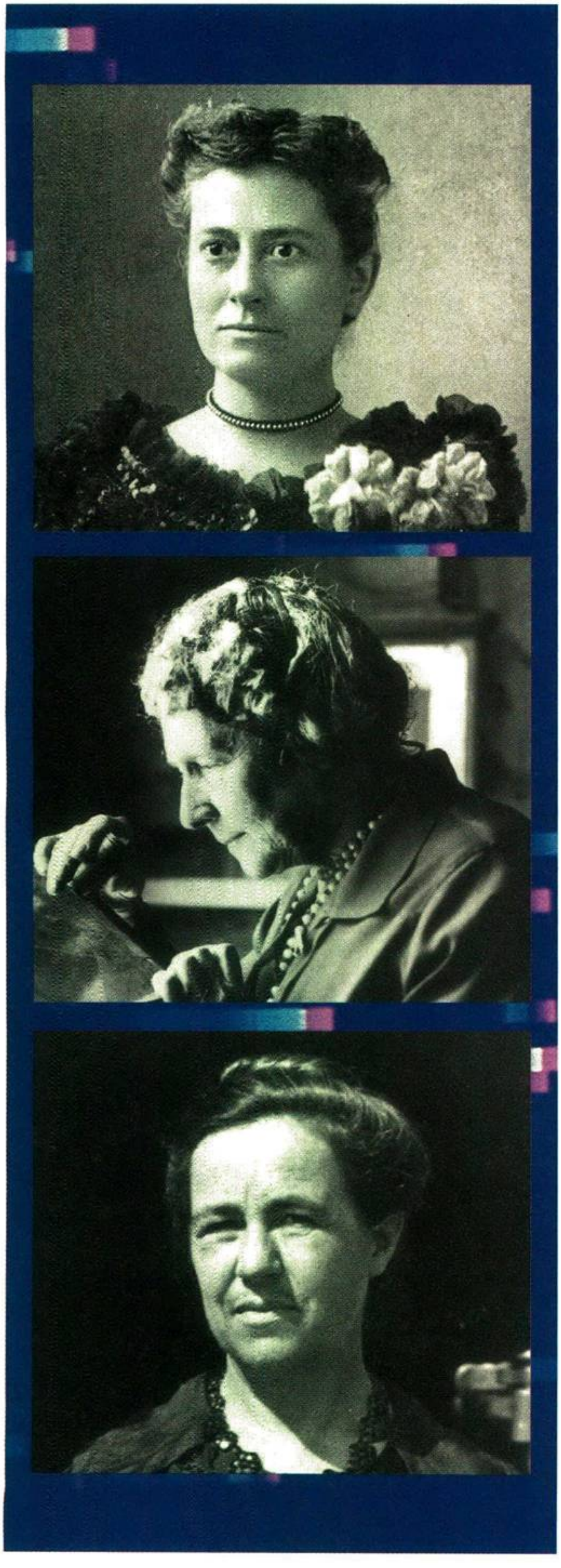
Astronomy professors have traditionally taught their students the mnemonic "Oh be a fine girl, kiss me" to help them remember the spectral sequence OBAFGKM. They often substitute "guy" for "girl" in our age, when we pay attention to matters of gender.

Today, we understand that Cannon's classes correspond to different stellar temperatures. The hottest stars, with temperatures around 40,000 kelvins (70,000° F), are called O stars. The sun, with a surface temperature of 5800 kelvins (10,400° F), is a G star. While Maury's system was far too complex to be useful, her discovery of important distinctions not captured by the original classification system was a crucial step forward, because it inspired the work of Danish astronomer Ejnar Hertzsprung.

Giants and Dwarfs

Hertzsprung was born into a prosperous family in Denmark. He studied chemical engineering and came to astronomy by working on the chemistry of photographic film. Looking closely at red stars using Maury's classification scheme, he found that stars in Maury's subdivisions moved at different rates and were therefore at different distances. The fainter stars moved rapidly, which meant that they were close to Earth. These stars appear faint because they are faint. Another group of red stars — Maury's c stars — barely moved at all, which meant that they had to be far away. These stars actually emit lots of light but appear faint because of their distance.

Hertzsprung realized that if a star has a low surface temperature, as was true for red stars, each square foot of surface area emits a relatively small amount of light. The only way such a star can emit a lot of light is if it has a large surface area. Today, we call these stars red giants and supergiants and recognize them as a late stage in the life of stars. When the sun becomes a red giant 6 billion years from now, its outer atmosphere will extend outside the present orbit of Earth.



Top to bottom: Three Harvard astronomers, Williamina Fleming, Annie Jump Cannon, and Antonia Maury, played pivotal roles in developing the modern stellar classification scheme. Harvard College Observatory

Hertzsprung's work established that there were two parallel series of stars — dwarfs and giants.

Hertzsprung's discovery meant that determining a star's temperature doesn't tell astronomers everything they need to know about it. A classification scheme based on temperature alone will mix together very different objects — faint red stars and red giants, apples and oranges. When he plotted stellar luminosities against Maury's spectral classes, he found that the stars fell into two main groups. Most of the stars, the dwarfs, fell in a band he called the main sequence. The others were the giants.

Hertzsprung published these findings in 1905 and 1907 in the journal *Zeitschrift für Wissenschaftliche Photographie* (*Journal of Scientific Photography*). This was, to put it mildly, an obscure publication not likely to be read by other astronomers. In later years, British astronomer Sir Arthur Eddington wrote to Hertzsprung, "One of the sins of your youth was to publish important results in inaccessible places."

At the same time, American astronomer Henry Norris Russell began looking at the same kinds of problems at Princeton University. But whereas Hertzsprung had been motivated primarily by trying to straighten out the classification of stellar spectra, Russell was trying to determine how stars evolve. He helped set up one of the first stellar distance measurement programs by using photographic plates instead of visual observations. So when he tackled the problem of red stars, he had direct data on their distances.

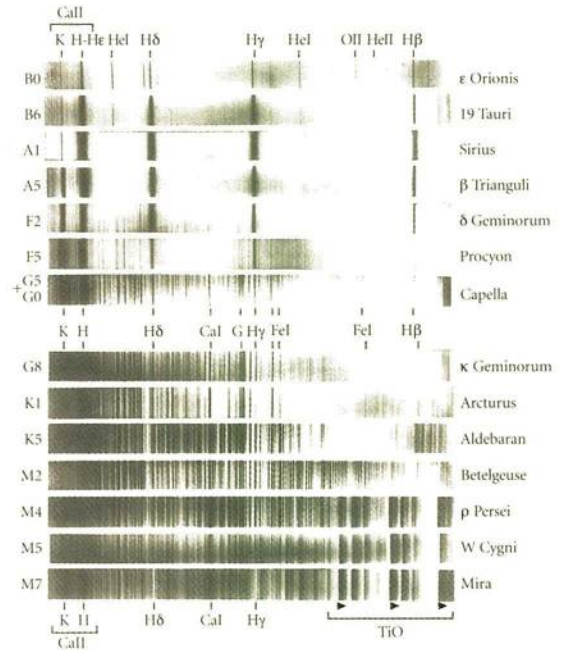
In 1909, Russell came to the same conclusion reached by Hertzsprung: There were two kinds of stars, dwarfs and giants. Like Hertzsprung, he also noted that for most stars, the hotter the surface, the more energy the star poured into space. Russell didn't announce his results until June 1913 at a meeting in London, and again in December at a meeting of the Astronomical and Astrophysical Society in Atlanta.

Because Russell was the first to publish the diagram in something close to its modern form, and because he presented his work in mainstream publications and meetings, he received the lion's share of credit when the usefulness of the diagram became apparent to other astronomers. For years it was known as the "Russell diagram." In 1933, Swedish astronomer Bengt Strömgren resurrected Hertzsprung's old papers and argued for his having made the discovery independently of Russell. It's been the HR diagram ever since.

Workhorse of Astronomy

All the complexity of the different kinds of stars is contained in this diagram. A star's temperature lies on the horizontal axis and its luminosity lies on the vertical. The HR diagram reveals three important groupings of stars. The most striking is the broad band running from the upper left (hot and bright) to lower right (cool and dim). This band, which includes the sun, is Hertzsprung's main sequence and includes stars that generate their energy by fusing hydrogen into helium (see "How Stars Shine," January 1998). The stars in the upper right hand corner (cool and bright) are the red giants.

The stars in the lower left (hot and dim) are called white dwarfs. These stars are no longer running nuclear reactions and shine only because they are cooling off. Think of them as stellar cinders. Although a few white dwarfs can be seen in both Hertzsprung's and Russell's original plots, neither one felt he had enough information to comment on this class of stars, and it was a decade later before astronomers came to recognize their true nature.



Astronomers classify stars according to the strength of dark spectral lines that indicate the presence of various elements.

The Observatory of the University of Michigan

But the main point was clear. When entered on the HR diagram, virtually all stars fall into one of these three classes, and within the main sequence, the hotter stars are more luminous than cooler ones. Hertzsprung and Russell independently discovered this fact about the main sequence — the former by plotting stars in large clusters, the latter from his distance measurement data.

Not only can every star be represented by a point on the HR diagram, but the life cycle of every star can be represented by a trajectory. For example, the sun begins on the right as a cool, contracting cloud of interstellar gas. As it warms up, it moves left toward the main sequence. Finally, when the nuclear fires ignite and the star begins to fuse hydrogen, it sits on the main sequence, staying more or less in one place until all the hydrogen in the core is consumed. The sun will spend about 11 billion years on the main sequence, of which 4.6 billion years have already passed. When the hydrogen in the core is exhausted, more complex nuclear reactions begin. These reactions will cause the sun's surface to cool and swell up, at which point the sun moves to the red giant part of the diagram. Finally, when all nuclear reactions stop, the sun becomes a hot cinder in space and moves down to the white dwarf region.

Thus, the HR diagram solved the problem of classifying stars. It orders the stars by placing them as specific points on the diagram, and it tells astronomers about stellar life cycles because each star's history and future can be represented by a single curve. No wonder that the HR diagram has become the workhorse of modern stellar astronomy!

George Mason University physicist James Trefil is a member of Astronomy's *editorial advisory board. He has authored or coauthored 27 books, the most recent of which is* Other Worlds. *The American Institute of Physics awarded Trefil the 2000 Andrew W. Gemant Award for linking physics to the arts and humanities.*

sky Show

november

The planets steal the show from the Leonid meteors this month.

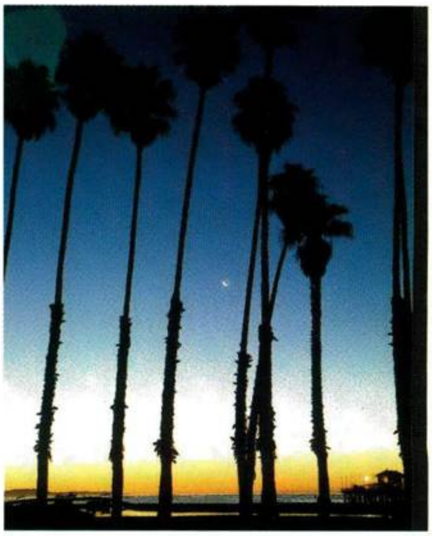
by Martin Ratcliffe and Alister Ling

▶ Recent research indicates that we still have a few years of great Leonid meteor showers to come. Unfortunately, during this year's peak on Friday night, November 17/18, a gibbous moon will wash out the fainter streaks. Nonetheless, it should be worth the effort to head out and watch, in case there is a repeat of the fireballs from two years ago. Remember to dress well and bring some warm drinks; the radiant doesn't rise until the early morning hours.

The gas giants Jupiter and Saturn will command our attention for the next several months. Watch Jupiter pull away to the right of Aldebaran, gradually closing in toward Saturn. Every couple weeks the planets move noticeably. Mark the 12th on your calendar to catch the moon sliding between Jupiter and Aldebaran. The slow dance of the jovian moons is a delight to watch.

Mercury puts on a fine morning show starting midmonth, easily seen between 6:30 and 6:45 A.M. low in the east. Cresting near magnitude –0.5, it is considerably brighter than the nearby 1st-magnitude star Spica, to the upper right. Compare their colors in binoculars. The razor thin crescent moon slips to the left of Mercury on the morning of the 24th. Use binoculars to pull in the soft glow of reflected earthshine — the new moon in the old moon's arms.

A Leonid meteor slips by on the left side of this photo of star trails. Traudel Koller-Anes



The moon stood by Venus in Southern California for this February 2, 2000, image. Mark Bright

Venus plays the evening star for the next couple months. At the end of each upcoming month the most beautiful conjunctions take place between the Goddess of Love and the moon.

When an asteroid moves in front of a star and observers time the disappearance, scientists use that data to figure out the asteroid's shape and size. You, too, can contribute if you're in the right place at the right time. Check on page 77 to see if you live in the shadow lands — if you do, you can catch a rare event this month when a naked-eye star disappears for a few seconds.

The coming of cool weather brings Orion back into the late evening sky. The Orion Nebula, M42, is a nearby example of a complex of dust and gas that exists in all spiral galaxies. Some of these HII regions can be seen in telescopes, and the brightest extragalactic regions appear as a fuzzy knot on the north side of the spiral M33. Another face-on spiral, M74, contains several clumps within its spiral arms.

2000 November

2 Mars is at aphelion (154.9 million miles from the sun), 4 P.M. EST
The moon is at apogee (251,268 miles from Earth), 10:31 P.M. EST

3 The moon passes 1.6° south of Neptune, 9 A.M. EST

4 First quarter moon is at 2:27 A.M. EST
The moon passes 1.8° south of Uranus, 11 A.M. EST

11 Full moon is at 4:15 P.M. EST

12 The moon passes 1.6° south of Saturn, 6 A.M. EST
The moon passes 2° south of Jupiter, 10 P.M. EST

14 Asteroid Bamberga is at opposition, 2 A.M. EST
The moon is at perigee (227,451 miles from Earth), 6:02 P.M. EST

15 Mercury is at greatest western elongation (19°), 1 A.M. EST

17 Leonid meteor shower peaks (page 76)

18 Last quarter moon is at 10:24 A.M. EST

19 Saturn is at opposition, 8 A.M. EST (page 74)

21 Asteroid Ceres is in conjunction with the sun, 5 A.M. EST
The moon passes 4° north of Mars, 1 P.M. EST

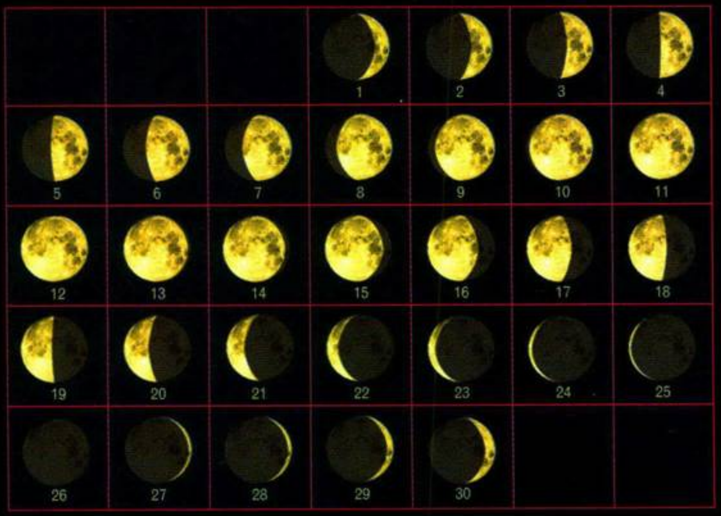
24 The moon passes 3° north of Mercury, 6 A.M. EST
Asteroid Thyra is at opposition, 2 P.M. EST

25 New moon is at 6:11 P.M. EST

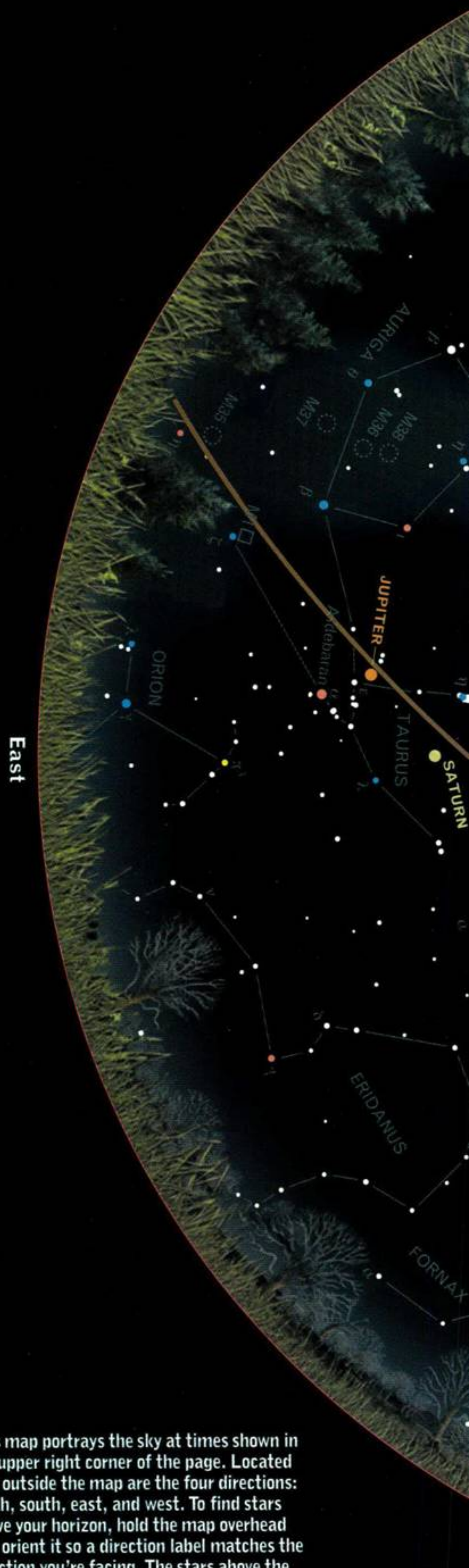
27 Jupiter is at opposition, 9 P.M. EST (page 74)

29 The moon passes 2° north of Venus, 1 P.M. EST (page 75)

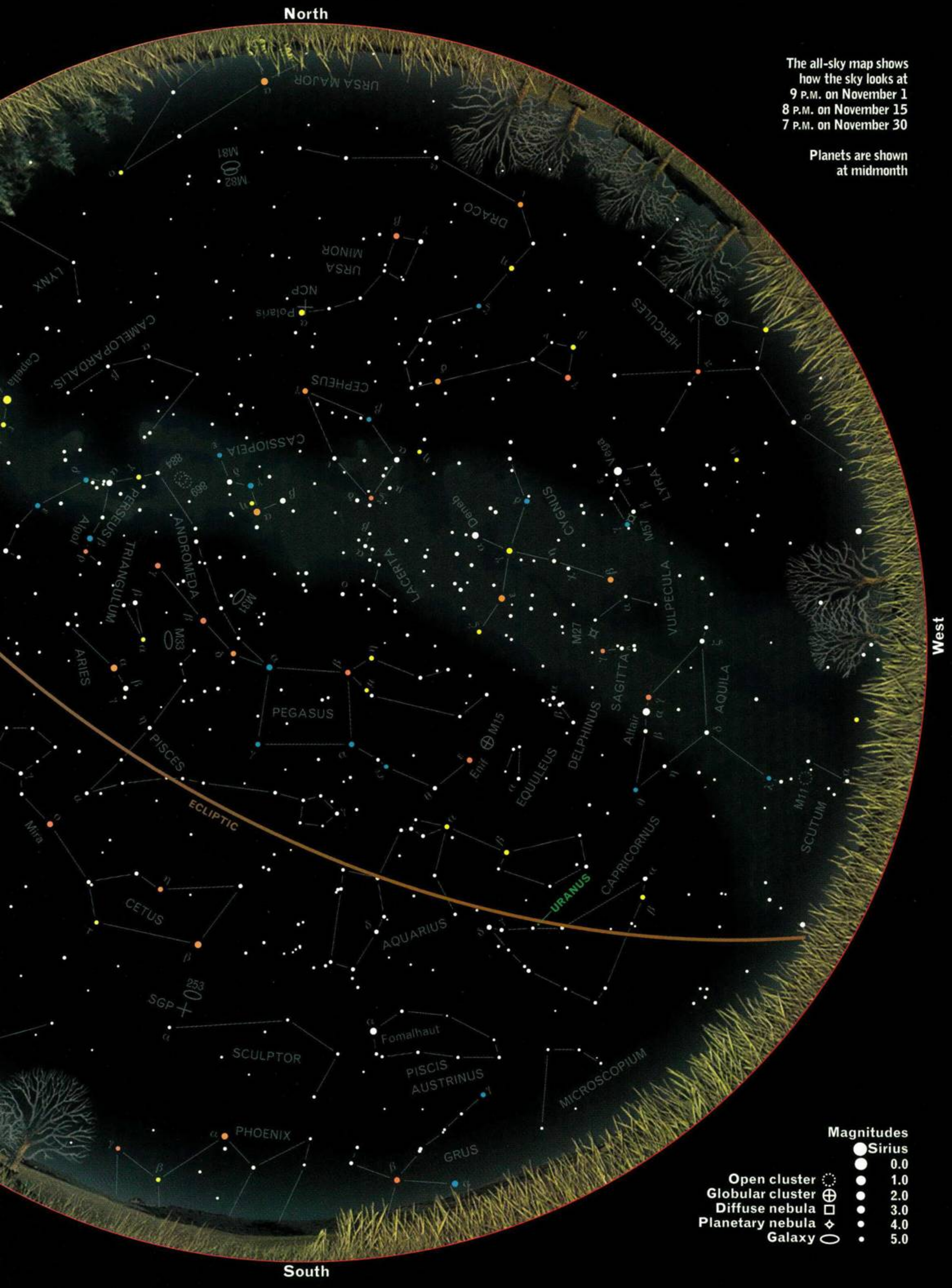
30 The moon passes 1.8° south of Neptune, 5 P.M. EST
The moon is at apogee (251,825 miles from Earth), 6:39 P.M. EST



SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
URSA MAJOR
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
CEPHEUS
HERCULES
M13
CASSIOPEIA
884
869
PERSEUS
Algol
TRIANGULUM
ANDROMEDA
M31
M33
ARIES
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
VULPECULA
M27
SAGITTA
AQUILA
Altair
DELPHINUS
EQUULEUS
Enif
M15
PEGASUS
PISCES
ECLIPTIC
Mira
CETUS
M11
SCUTUM
CAPRICORNUS
URANUS
AQUARIUS
253
SGP
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS

The all-sky map shows
how the sky looks at
9 P.M. on November 1
8 P.M. on November 15
7 P.M. on November 30

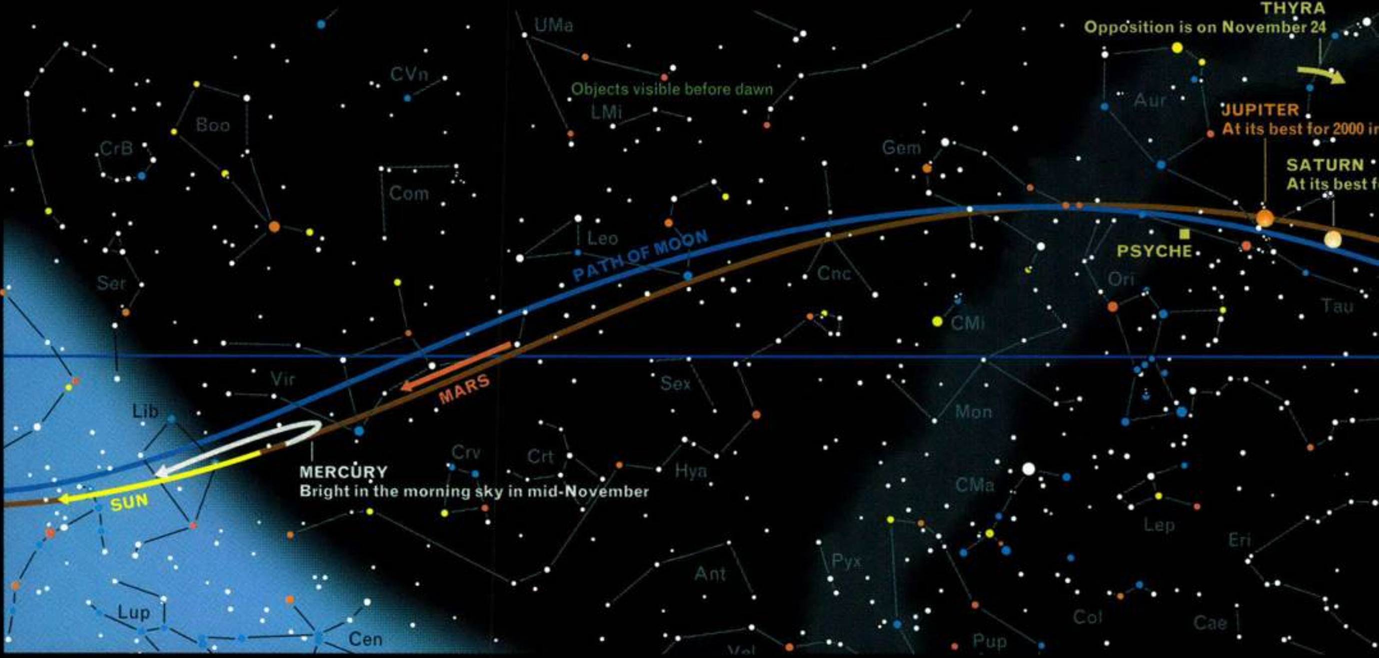
Planets are shown
at midmonth

Magnitudes

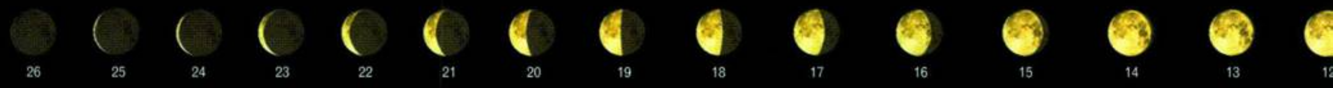
	●	Sirius
	●	0.0
Open cluster ⁘	●	1.0
Globular cluster ⊕	●	2.0
Diffuse nebula □	●	3.0
Planetary nebula ⟡	●	4.0
Galaxy ⬭	•	5.0

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects


UMa
CVn
Objects visible before dawn
LMi
Boo
CrB
Com
Leo
PATH OF MOON
Ser
Vir
MARS
Lib
SUN
MERCURY
Bright in the morning sky in mid-November
Crv
Crt
Hya
Sex
Lup
Cen
Ant
Gem
Cnc
CMi
Mon
CMa
Pyx
Pup
THYRA
Opposition is on November 24
Aur
JUPITER
At its best for 2000 i
SATURN
At its best f
PSYCHE
Ori
Tau
Lep
Eri
Col
Cae

To locate the moon in the sky, draw a line from the phase s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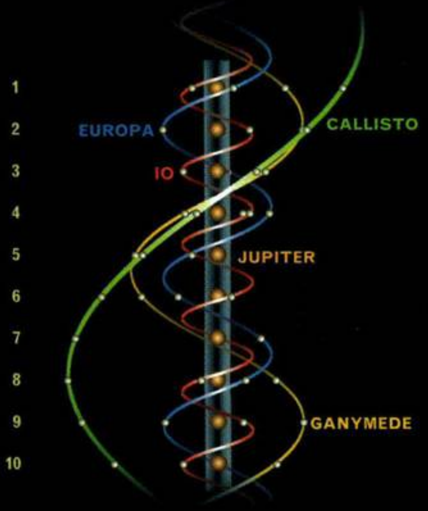
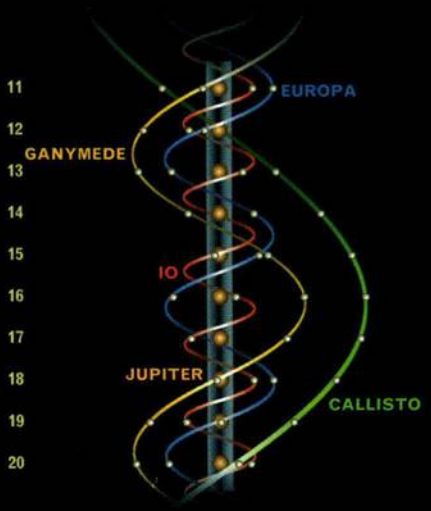
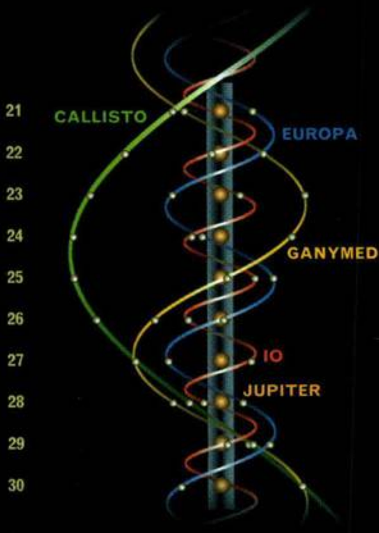
PLANETS	**MERCURY**	**MERCURY**	**VENUS**	**MARS**	**JUPITER**
Date	November 15	November 30	November 15	November 15	November 15
Magnitude	−0.5	−0.7	−4.1	1.7	−2.8
Angular Size	6.8''	5.2''	14.7''	4.3''	48.4''
Illumination	59%	91%	75%	95%	100%
Distance (AU) from Earth	0.991	1.296	1.132	2.189	4.071
Distance (AU) from Sun	0.333	0.415	0.728	1.665	5.032
Right Ascension (2000.0)	14h09.2m	15h28.0m	18h10.1m	12h26.7m	4h25.1m
Declination (2000.0)	−10°33'	−17°43'	−25°32'	−1°28'	20°42'

Jupiter's Moons

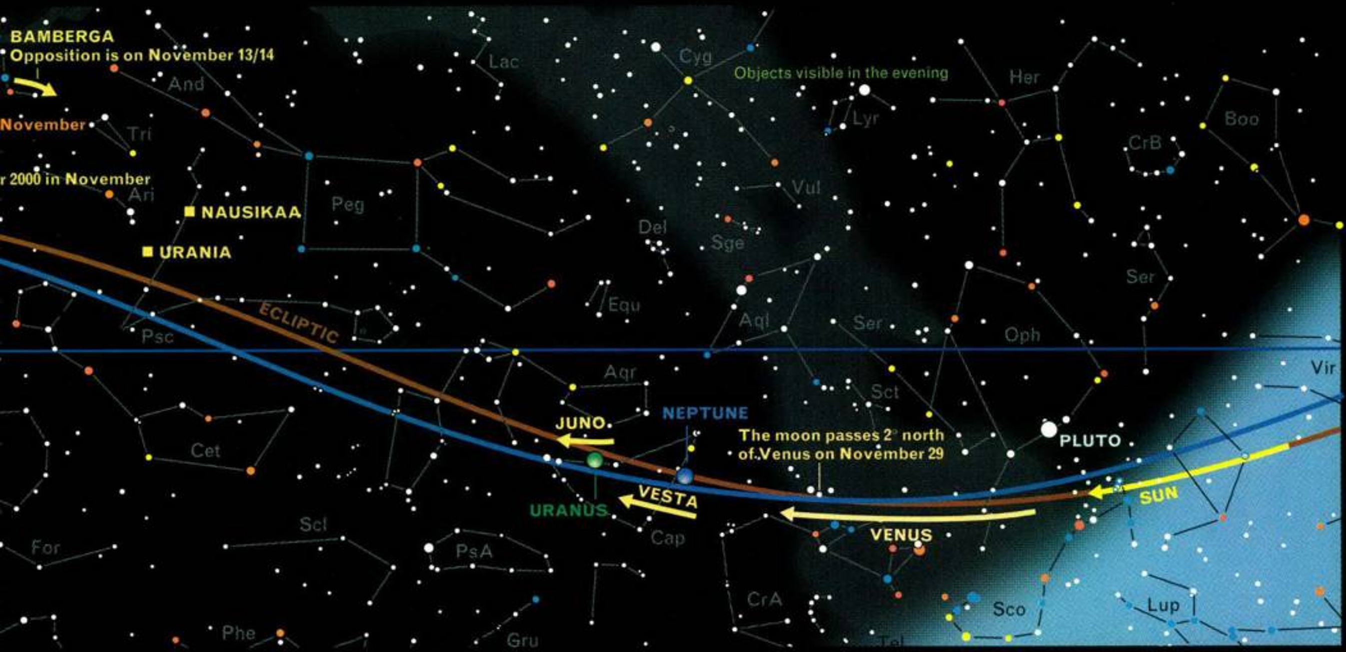
Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope.



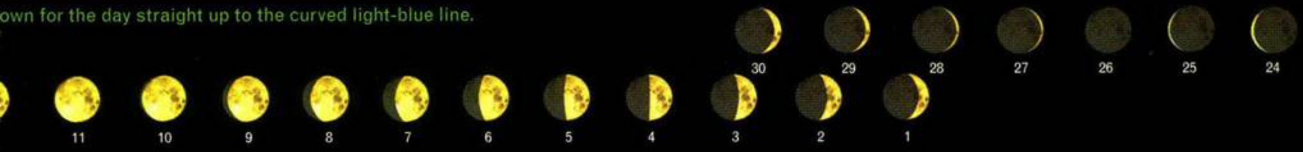




during the month.


BAMBERGA
Opposition is on November 13/14
November
r 2000 in November
NAUSIKAA
URANIA
ECLIPTIC
Objects visible in the evening
And
Tri
Ari
Lac
Cyg
Lyr
Her
Boo
CrB
Peg
Vul
Del
Sge
Equ
Aql
Ser
Oph
Psc
Aqr
Sct
Vir
Cet
JUNO
NEPTUNE
The moon passes 2° north of Venus on November 29
PLUTO
URANUS
VESTA
SUN
VENUS
Cap
Scl
For
PsA
CrA
Sco
Lup
Phe
Gru
Tel

own for the day straight up to the curved light-blue line.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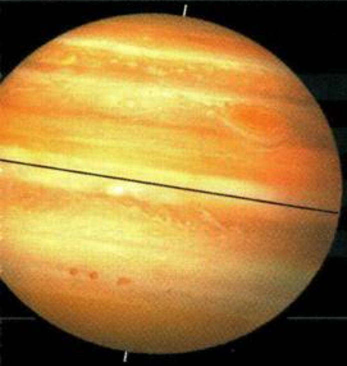
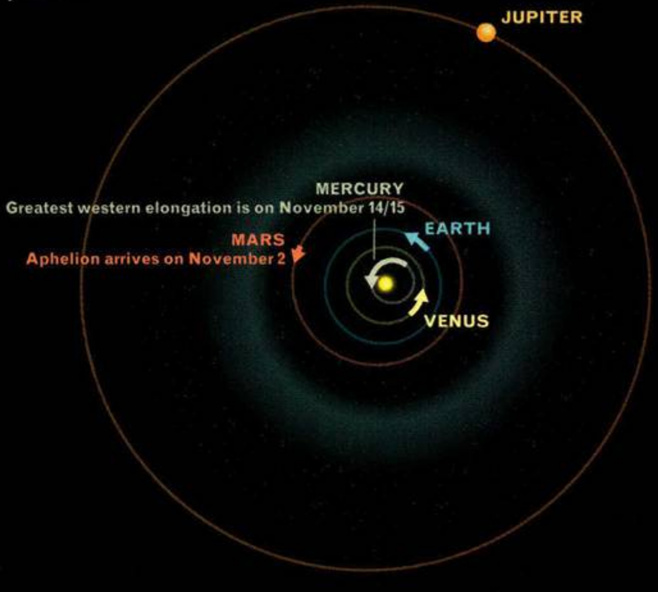
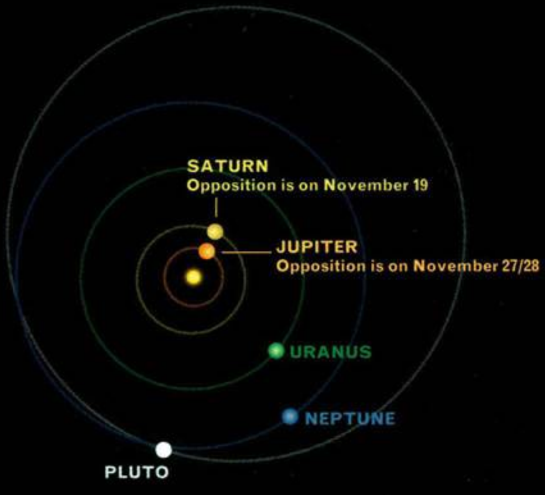


SATURN	**URANUS**	**NEPTUNE**	**PLUTO**
November 15	November 15	November 15	November 15
−0.3	5.8	7.9	13.9
20.4"	3.5"	2.2"	0.1"
100%	100%	100%	100%
8.136	20.031	30.415	31.239
9.122	19.954	30.109	30.322
3h44.5m	21h18.9m	20h25.3m	16h47.5m
17°25'	−16°24'	−19°04'	−11°57'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
MERCURY
Greatest western elongation is on November 14/15
EARTH
MARS
Aphelion arrives on November 2
VENUS


SATURN
Opposition is on November 19
JUPITER
Opposition is on November 27/28
URANUS
NEPTUNE
PLUTO

M74: A Prince of Spirals

Of all the bright galaxies in the Messier catalog, there are only a small number of face-on spirals. Without doubt the grandest is the Whirlpool, M51. But interesting in its own right is M74, the sole Messier object in Pisces.

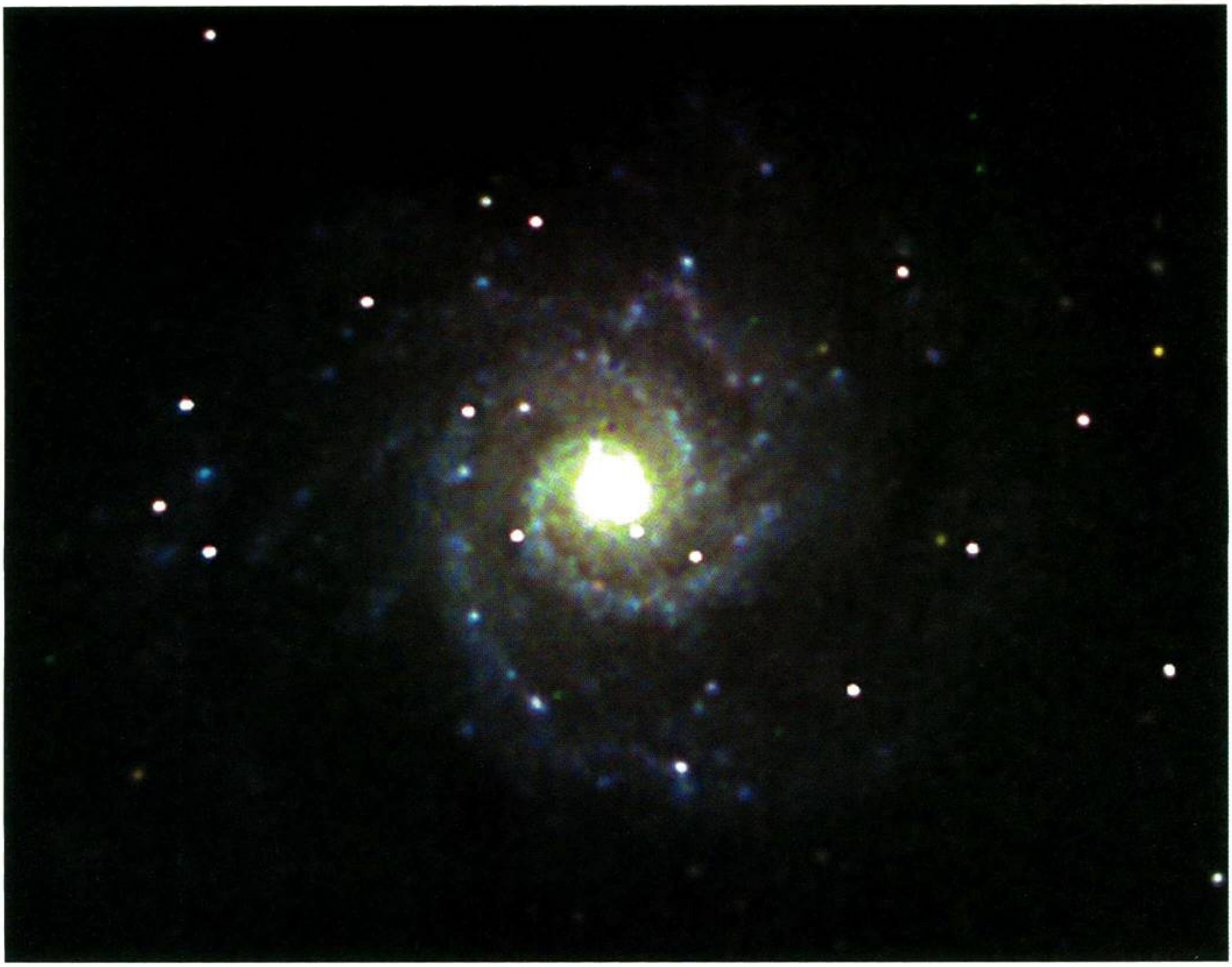
This 9th-magnitude galaxy is prominent enough in a dark sky to appear in small telescopes. Although a princely spiral, it gets an unjustified bad rap from the springtime Messier marathons. Its position in spring twilight makes it challenging. But this is late fall, and Pisces now climbs higher in the east.

To find M74, simply take the two bright stars of Aries and slide in a straight line to 101 Piscium, then backtrack three moon diameters. A 4-inch scope will reveal a bright core surrounded by a large, dim glow. Shade your eyes and relax while you scan the field with averted vision. This off-center viewing turns out to be the most sensitive part of your retina for low-light situations.

If the seeing is good, the best view of any galaxy comes at higher power because hidden structures are magnified enough to see. Right in the middle of M74 sits a starlike core surrounded by a pretty, uniform, circular disk. As you get accustomed to the darkness, a couple faint field stars pop out, masquerading as potential supernovae.

With scopes of 12 inches and up, the two-armed spiral form rises out of the halo, but you'll probably need to be past 150x to see it well. Just as with M51 and our own Milky Way, the spiral arms of M74 are dotted with gas clouds and clusters, called HII regions. Because they are so far away, they appear as tiny faint clumps, or knots.

If our atmosphere is its usual turbulent self, you might only see some vague mottling at medium power. On the other hand, a calm night will allow you to boost the magnification past 300x, at which point three or four knots will tickle your retina. Georgia amateur Richard Jakiel tracked down eight knots on a dark, steady night.



The spiral galaxy M74 is a 9th-magnitude target in Pisces. Jack Newton

Jupiter and Saturn Reach Opposition

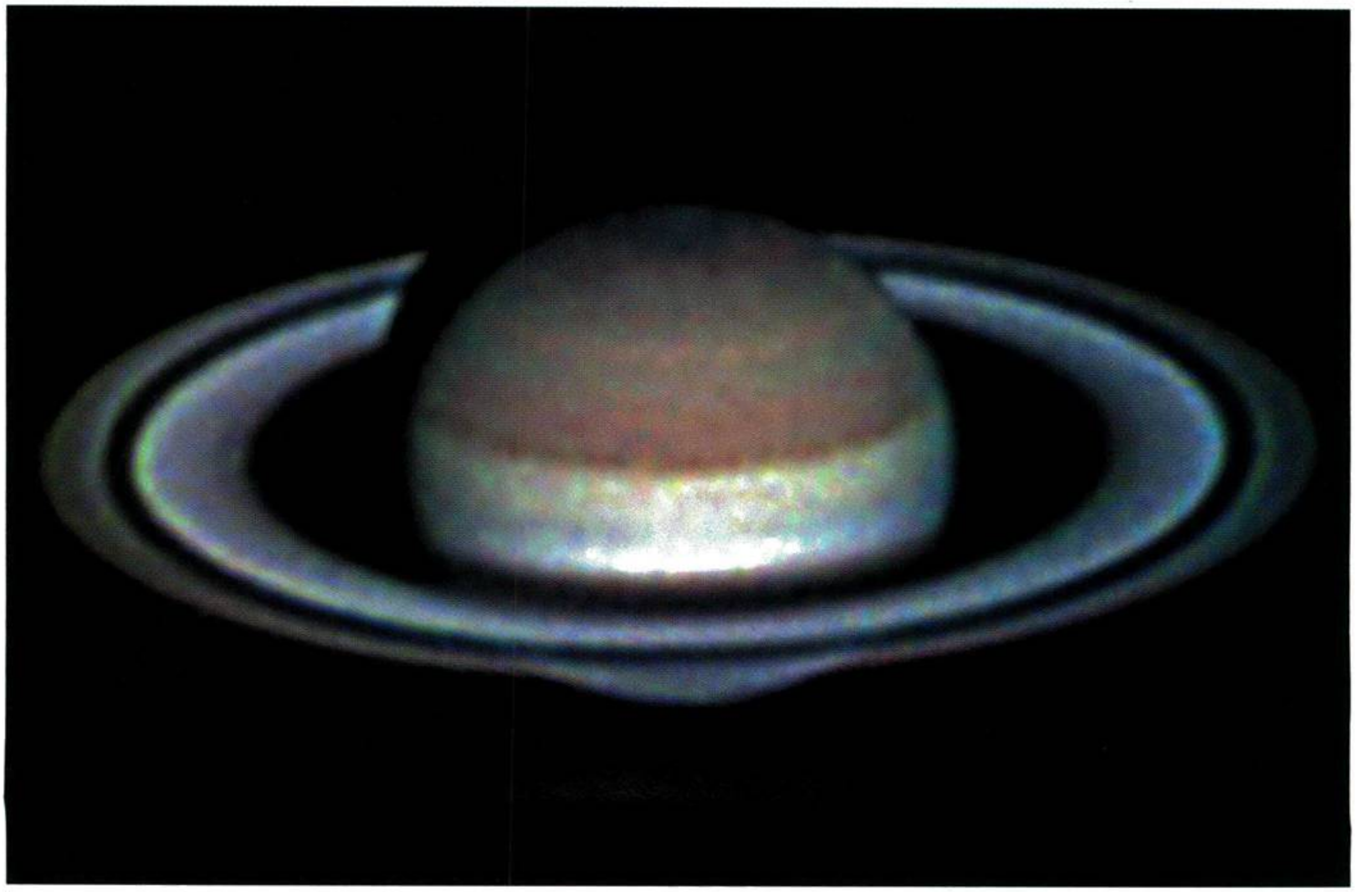
The two largest planets in the solar system, Jupiter and Saturn, are on display every night during November, when they reach opposition. Venus reappears after a long and slow climb out of the sun's evening twilight glow. Let's look at Venus first, because it sets soon after the sun.

On November 1 **Venus** sets two hours following sunset. The "evening star" hangs low in the southwest, about 8° above the horizon an hour after sunset (approximately 6:30 P.M. local time). You can easily spot it as a brilliant "star" shining at magnitude –3.9. On the same night a lovely 5-day-old crescent moon hangs low in the south-southwest. By November 5 a telescopic view of Venus appears to show it with a temporary moon — but in reality it is the magnitude 3.0 star Theta (θ) Ophiuchi lying 4 to 5' away. Nearly two weeks later Venus lies within a half degree of Lambda (λ) Sagittarii.

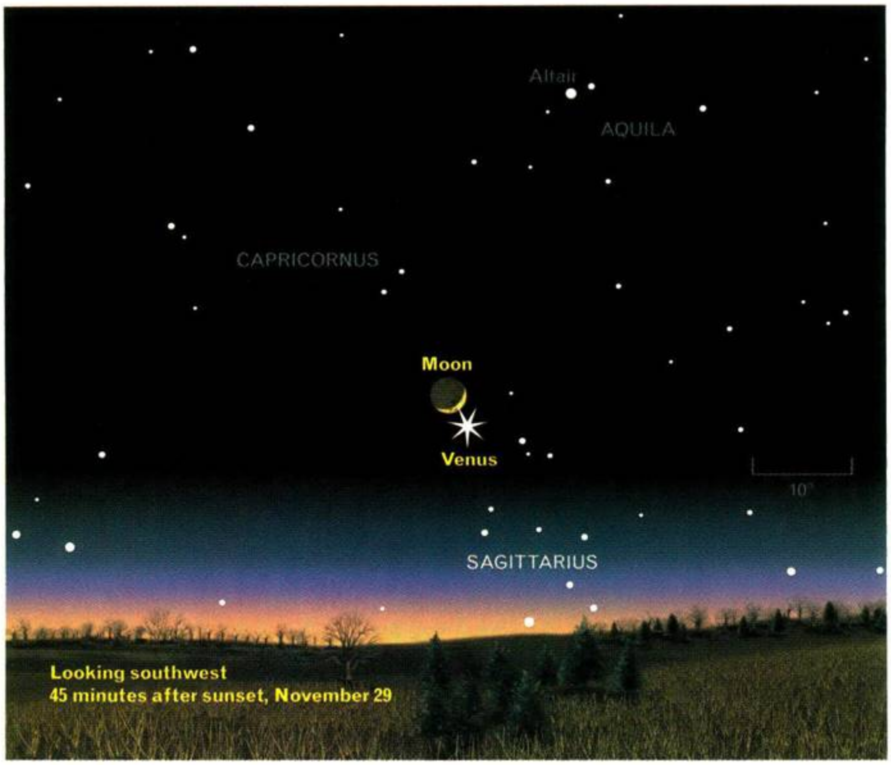
The best evening view of Venus occurs on November 29, when a 4-day-old crescent moon hangs 2° north of the brilliant planet. By this time Venus sets three hours after the sun. The close conjunction with the moon provides a spectacular opportunity for some wide-angle photography.

While the brilliance of Venus provides a dazzling attraction in the early evenings, as soon as it sets **Jupiter** and **Saturn** take center stage. The pair of giant planets rises in the east as Venus sets in the west. Jupiter and Saturn are well settled now in the constellation Taurus the Bull. Both reach a point called opposition during November — a point in their orbits where they lie exactly opposite the sun in our sky. The date of this event is useful because it tells us when the planet will be above the horizon all night. Saturn's opposition date occurs first, on November 19, followed on the 27th by Jupiter, which lies farther east.

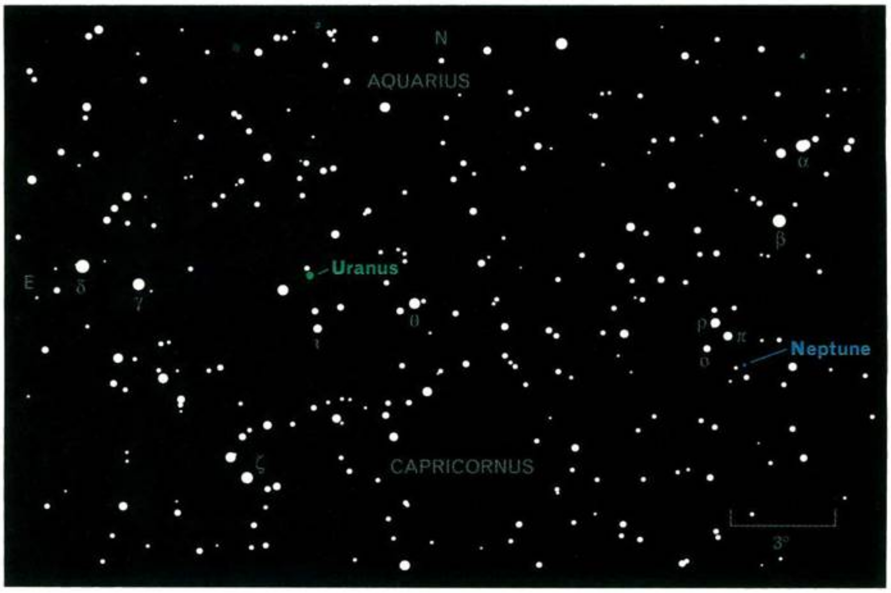
Saturn reaches a respectable magnitude –0.4 at opposition. The Ringed Planet lies 5° northeast of the full moon on November 11 and just south of the Pleiades. At 8.4 astronomical units (780 million miles) from Earth, Saturn is slightly closer than usual because it is heading toward perihelion (its closest orbital point to the sun), which it will reach in 2003. Saturn's rings tip more toward Earth this year, providing a fine view through any telescope. Although the disk of Saturn reveals little through telescopes and spans only 20" across, its rings contribute more than double this diameter, making it a truly spectacular sight. Small telescopes reveal at least two major rings, perhaps three if the observer is patient and spends time examining them. Most noticeable is the Cassini Division, a black separation between the outer A ring and the inner



Saturn will be in a prime position for observing throughout November. John Chumack



Looking southwest
45 minutes after sunset, November 29



B ring. Some of Saturn's moons are visible each night also, particularly the magnitude 8.3 Titan. Titan is the only moon in the solar system to have an appreciable atmosphere. This unique satellite is the target of the Huygens lander, which is currently aboard the Cassini spacecraft and due to meet its target in 2004.

Jupiter is the brighter of the pair of giant planets, shining at magnitude –2.8, making it the brightest object in the night sky after Venus and the moon. It starts out lying 4° north of Aldebaran on November 1. Look at their contrasting colors — Jupiter reflecting the yellowish light of the sun and Aldebaran burning a bright orange. Throughout the month Jupiter travels slowly west relative to the stars of Taurus. As the largest planet in the solar system, Jupiter never disappoints the telescopic viewer. The disk spans almost 49" — making its atmospheric features quite easy to see. First views of the planet will reveal the two dark parallel equatorial belts. Some observers stop there, but continue on — take some time to watch the planet closely, and some of the delicate features will jump out as clear moments of viewing occur. Jupiter's four most notable moons (Io, Europa, Ganymede, and Callisto) continually dance around the planet, in periods ranging from 1.8 days to more than two weeks.

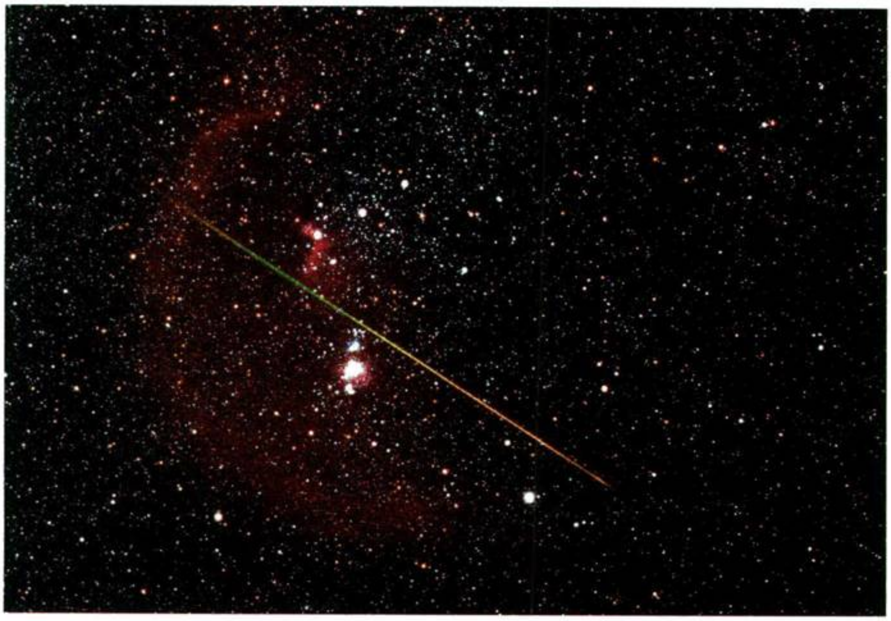
The other two giant planets in our solar system, **Uranus** and **Neptune**, are wandering among the stars of Capricornus the Sea Goat. Only 1° separates Neptune from Pi (π) Capricorni, a magnitude 5.2 star in western Capricornus. Neptune shines at magnitude 7.9. Uranus lies within the same low-power telescopic field of view as Iota (ι) Capricorni, a magnitude 4.3 star near the northeastern end of Capricornus. Blue-green Uranus is an easy binocular object at magnitude 5.8.

Mercury makes an excellent early morning appearance and reaches greatest western elongation on November 15. Between November 10 and November 20 Mercury puts on a fine display. It lies 9° to the east of Spica on November 12, rising in the east-southeast about 90 minutes before sunrise. Shining at magnitude –0.3, it outshines 1.0-magnitude Spica. Each following morning Mercury appears a little brighter, reaching magnitude –0.7 on November 20, but it quickly slips into dawn's glow.

Mars hangs high above Mercury at magnitude 1.7. Its dim red glow will rebound to create a bright apparition during its return to opposition in June 2001. On November 12 Mars passes very close to Eta (η) Virginis, a dim magnitude 3.9 star in the bowl of Virgo. Insomniacs can find Mars rising shortly after 3 A.M. local time in the middle of the month.

sky Show

Meteors and Moons



A Leonid meteor appears to pass through Orion, separating the belt stars from the sword stars. Ian McMichael and Alan Sailer

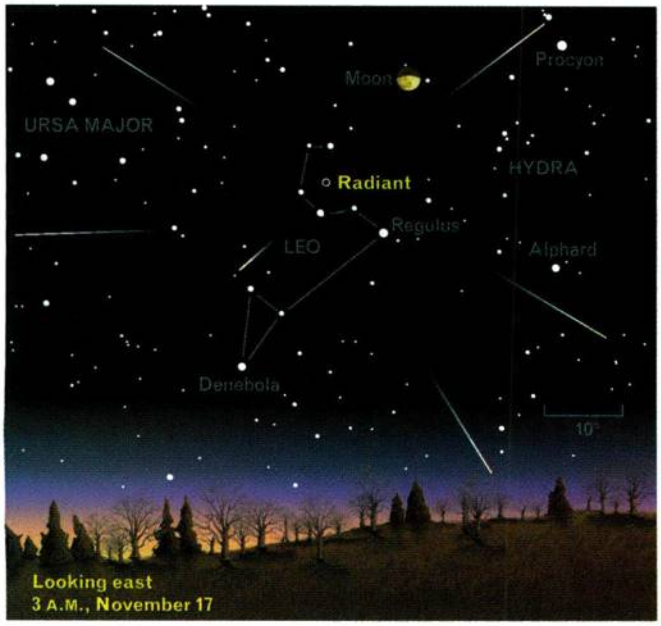
The Much-Loved Leonids

Our understanding of the Leonid meteor shower has improved by leaps and bounds during the past two years, especially with the help of a correct prediction for 1999's meteor storm. Those same astronomers have made new predictions regarding the 2000 and 2001 passages of Earth through the orbital plane of Comet 55P/Tempel-Tuttle, the parent comet of the Leonid meteor shower.

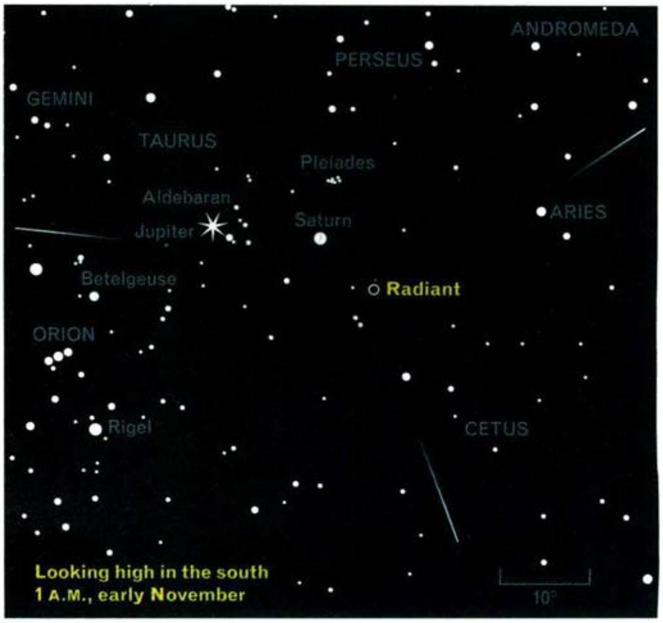
This year Earth passes very close to two predicted trails of cometary debris left during the 1733 and 1866 passages of the comet across Earth's orbital plane. Unfortunately, a last quarter moon interferes with viewing on November 17 and 18. However, monitoring what happens this year will be important in adding to our understanding of what might happen next year, because in 2001 Earth passes right through the predicted position of both the 1733 and 1699 trails. In 2001 a three-day-old moon will be well out of the picture, providing perfect viewing conditions. But keep an eye on the skies this year around the time of maximum. Any Leonids that you do see through the moonlight are likely to be very swift, because most of the material strikes Earth almost head-on.

The Temperate Taurids

A minor shower, the Taurids typically produce rates of 5 meteors per hour, and the radiant is in two parts, one that peaks around November 5 and another that peaks around November 12. Unfortunately for meteor showers this November, the moon interferes with both peaks, but the shower's activity starts October 25, allowing some better early observing of the shower. The Taurids are worthy of some attention because in recent years, notably in 1995 and again in 1998, a series of brilliant fireballs were observed. Most Taurids are yellowish in color and quite slow moving. Set a camera on a tripod pointing toward Taurus's region of sky to catch star trails and you may also snag a meteor.



Looking east
3 A.M., November 17



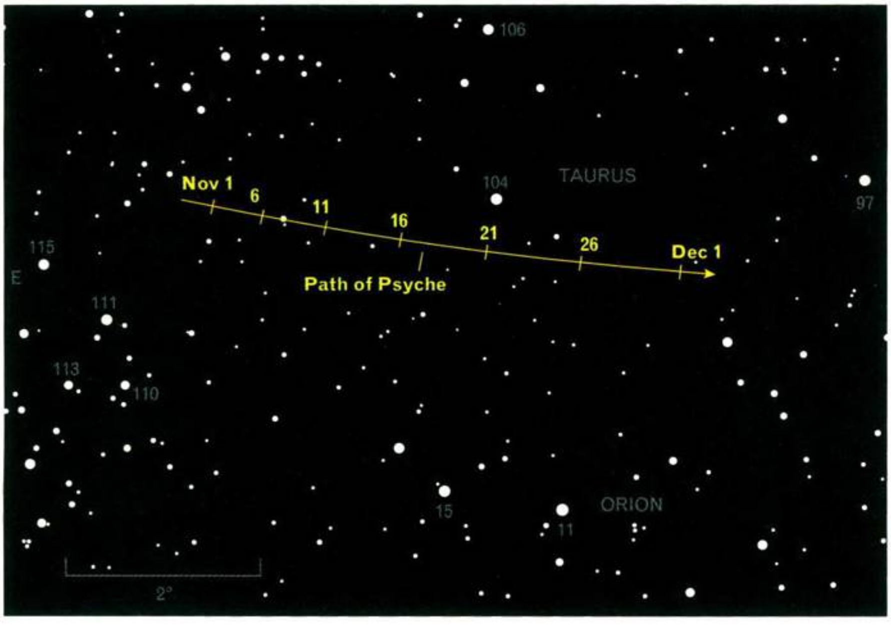
Looking high in the south
1 A.M., early November

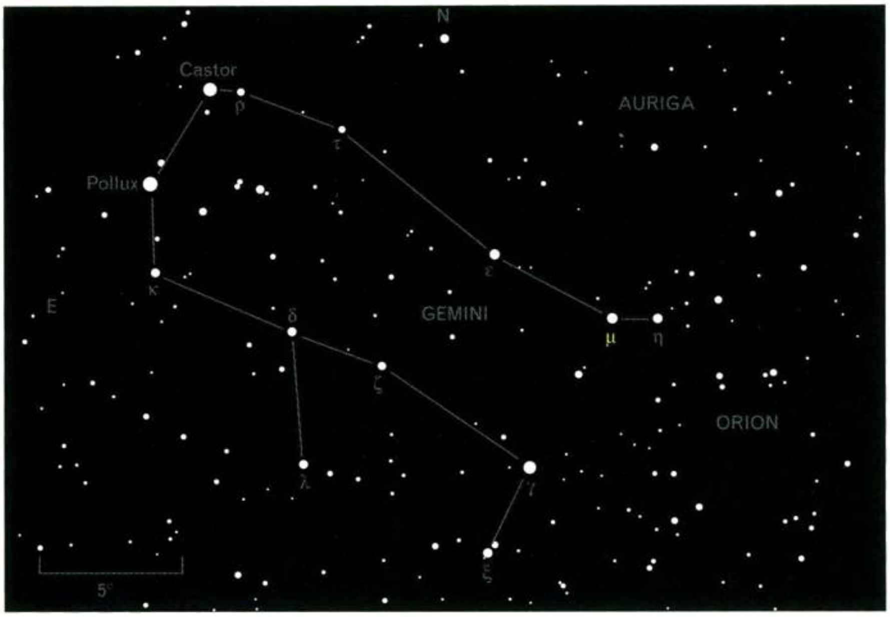
Psyche Sets Her Sights on Aldebaran

There's a good chance that at some point your telescope will be turned toward the striking pair of Jupiter and Aldebaran rising in the east this month. Tucked just a few fields away is one of the solar system's rocky remnants. Sixteenth on the discovery list, Psyche is a modest 160 miles (260 km) across and was named after a princess whom Cupid loved.

You can find Psyche about halfway between Aldebaran and the supernova remnant known as the Crab Nebula (M1). Psyche lies not far from a 5th-magnitude star, 104 Tauri. After midmonth, the asteroid is just a couple moon diameters from 104 Tauri. Many of the stars in the Taurus region of the Milky Way are the same brightness as 10th-magnitude Psyche, so you'll probably need the chart below to help you spot the interloper.

Make a quick sketch of the field so that on a following night you can come back and see which star moved. As a bonus, on the nights of November 15 to 17, the asteroid 32 Pomona slides a mere 10', ⅓ of a lunar diameter, north of 104 Tauri. At magnitude 11.6 Pomona is considerably fainter than Psyche, so try some higher magnification, from 150x to 200x, and hope for clear and steady skies.





Only the Shadows Know

An excellent opportunity awaits lucky observers to stand in the shadow of an asteroid. As a faint asteroid moves in front of a bright star, like a high-flying plane blotting out a small part of the sun, a shadow sweeps across the ground. If you are in the narrow path, you will see a star wink out for a few seconds.

On Sunday night, November 5 to 6, around midnight EST, a 9th-magnitude star in Cetus (R.A. 0h17m, Dec. –14°20') will suddenly disappear, up to a maximum of 24 seconds, as the faint asteroid 381 Myrrha hides it from observers living across the southernmost states.

If you want to see one of the brightest stars occulted by an asteroid, you'll probably have to drive to get on the shadow path, stretching from South Carolina through northern Illinois up to west central Minnesota and northwestward to Cold Lake, Alberta. A naked-eye star, 3rd-magnitude Mu (μ) Geminorum, drops out of sight near dawn on Monday morning, November 20, when 752 Sulamitis crosses its path for about 13 seconds. Many camcorders are sensitive enough to record this event. In addition, Mu Gem is a red giant star, so its disappearance will be gradual, not instantaneous.

The predicted paths can shift after the asteroids' orbits are refined, so you would be wise to check out the asteroid occultation section of the IOTA website at www.lunar-occultations.com/iota for updated information. ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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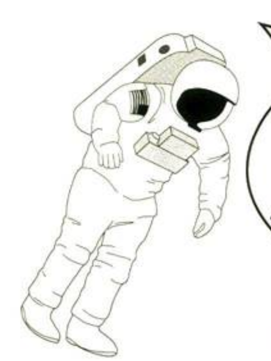

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Inside REFLECTORS

Introduce your child to the sky with a simple telescope.

by Glenn F. Chaple, Jr.

A telescope is an optical marvel, a "spaceship" that can intellectually transport you almost anywhere in the universe. Once a child learns about the moon, planets, and stars, he or she may want a telescope to explore these amazing space places. But telescopes can seem complicated — even for adults. Last month we showed you how a refracting telescope works. This time, we'll move on to the reflector. First, let's review some of the telescope basics you and your child or students need to know.

A small reflector gives young observers portability, sharp images, and all-purpose flexibility for viewing planets and deep-sky objects. *Astronomy*: Jim Forbes

Galaxies such as the "Leo Trio" (M65, M66, and NGC 3628) show crisply in reflectors. Jason Ware

Contrary to popular belief, the main advantage of a telescope is not its magnifying power. Sure, the sight of the moon enlarged a hundred times guarantees a gasp of wonder from a child. But it's the telescope's light-gathering power that lets astronomers explore the far reaches of the universe. A telescope collects light — lots of light — enabling astronomers to study stars, nebulae, or galaxies too faint to be seen with the unaided eye. There's a third telescope "power" — resolution, the ability to produce a sharp image.

Telescopes come in three major optical designs — the refractor (which collects light with a convex objective lens), the reflector (which does the job with a concave mirror), and a refractor-reflector hybrid called the catadioptric scope. All three telescope designs have two main parts, a tube assembly that holds the optics and a mount to support the tube assembly. There are three common types of mounts, the simple altazimuth (which allows side-to-side and up-and-down motions), the more sophisticated equatorial (which follows star motion better than the alt-az), and the Dobsonian (a variation of the altazimuth, which has become popular with owners of large-sized reflectors).

Inside a Reflecting Telescope

Place a reflecting telescope beside a refractor, and you'll notice some major differences. The eyepiece on a refractor is located at the back end (bottom) of the tube, while the reflector's juts out at a right angle from the top. There's a large lens (the objective) at the front end of the refractor. The front of the reflector's tube is wide open. Look down that opening, and you'll see a large circular mirror (the reflector's objective) at the bottom of the tube. Despite these differences, the reflecting

MAKING ADJUSTMENTS

For the beginner, collimating (aligning) the optics of a reflecting telescope can be a daunting chore. But after you've done it once or twice, collimation is a fairly simple task. It's even easier if you ask a youngster for assistance. Here's what you do:

Aligning the Diagonal. With the eyepiece removed, look into the focuser. You should see the diagonal mirror just inches from your eye. On the diagonal is a reflected image of the main mirror. Adjust the diagonal (be careful not to touch its reflective surface) until the image of the main mirror is centered in the diagonal.

Aligning the Primary. Once the image of the main mirror is centered in the diagonal, study it closely. You should see a reflected image of the diagonal and your eye. If the diagonal/eye image is centered in the image of the main mirror, you're in luck — the optics are properly collimated. If not, the main mirror is out of alignment. Most primary mirrors are aligned by three adjustment screws located at the bottom of the tube. Here's where your assistant comes in. Ask him or her to turn the screws one-by-one while you look into the eyepiece holder. By trial and error, you should eventually center the image.

HELP FROM YOUR FRIENDS

A great way to learn about telescopes and astronomy in general is to read a magazine such as *Astronomy*. The articles are written by people who want you to enjoy the night sky the way they do. Helpful information can also be found in the astronomy handbooks at your local library or bookstore.

Another handy resource is an astronomy club. Here you'll find people who are eager to help you with your telescope problems or questions. Even experts benefit from association with a local astronomy club.

BATTLE OF THE TELESCOPES

Which is better for backyard astronomy — the refractor or the reflector? Even the experts don't always agree. Truth is, neither type "does it all." Some amateur astronomers even own one of each. Here's a refractor vs. reflector comparison:

The refractor tends to produce a sharper image at high magnifications — important if you want to see lunar and planetary detail. Because its optics are sealed in the tube, the refractor requires relatively little cleaning and maintenance. Unfortunately, refractors are expensive for their size. A 4-inch refractor can cost $1,000 or more, while a reflector of the same aperture might be purchased for one-third that price. Another minus — the refractor's eyepiece is placed in an awkward position, requiring stooping when the scope is aimed overhead.

The reflector is the telescope of choice for astronomers who study large but faint sky objects. Reflectors are relatively inexpensive, and you should be able to get a large telescope that will collect lots of light and unveil dim nebulae.

NEWTON'S REFLECTOR

We may not be certain who invented the refracting telescope, but the history of the reflector is clearer. The first reflecting telescope was produced by Isaac Newton in 1668, six decades after the refractor was invented. His design, which used a concave mirror to collect light and a flat diagonal mirror to redirect that light toward the eyepiece, is the one most often used today. In his honor, we refer to it as the Newtonian reflector. Unfortunately, Isaac wasn't pleased with his telescope. The mirror, made out of metal, produced an image that was too faint for his liking.

A less common reflector design is the Cassegrain, invented just six years after the Newtonian. The Cassegrain design still uses a concave primary mirror. Light hitting the primary mirror strikes the slightly convex secondary mirror, which reflects back to the primary. That light then passes through a small hole in the center of the primary mirror and onto the eyepiece located at the bottom of the tube.

HOW TO CLEAN A MIRROR

Cleaning the primary mirror of a reflecting telescope may seem like a tedious chore — the astronomical equivalent of mopping the kitchen floor. Enlist a youngster for this task to make it more fun.

Carefully remove the main mirror from its cell in the tube, taking care not to touch the surface with your fingers. Using a camel's hair brush (available at any camera shop), gently whisk away loose dust. Hold the mirror securely around the edges and place it under a faucet, rinsing it with lukewarm water.

Moisten a clean cotton ball and add a drop or two of mild dishwashing detergent. Start at the center of the mirror, and with light, outward strokes, swab the mirror's entire surface. Give it a final rinse with distilled water, and place the mirror on a towel in a safe place to dry. Elevate one end of the mirror slightly so excess water runs off. When the mirror is completely dry, place it back in the scope. Recollimate it, and you're back in action.

telescope weaves the same optical magic on starlight that a refractor does.

The refractor works by collecting incoming light with a convex objective lens and concentrating the light to form a small, upside-down image. A reflecting telescope does the same thing by using a concave (curved inward) objective mirror. Light passes through the open end of the tube, travels down, and strikes the objective mirror. It's then reflected and concentrated to a point where a small upside-down image is formed. The distance between mirror and image is the mirror's focal length. The more highly curved the mirror, the shorter the focal length.

Last time, we explained how to demonstrate to youngsters the image formed by the objective lens of a refracting telescope. Your best bet for an objective mirror substitute is a circular shaving or make-up mirror. Again, you need to be in a darkened room on a day when it's bright outside. All the shades in the room should be drawn. Next to that window, tape a piece of white paper (unless the wall itself is white). Standing a few feet back, aim the mirror toward the window, tilting it slightly so it reflects light onto the paper. Move the mirror in and out until an image forms on the paper.

Magnifying the image formed by a concave mirror can present a problem. The mirror reflects light back toward the source, placing the image between the mirror and the light source. Try to view the image with a magnifier (the eyepiece), and your head blocks the incoming light. What to do? Look down the tube of a Newtonian reflecting telescope (see "Newton's Reflector" sidebar), and you'll notice a small obstruction just inches from the opening. It holds a small flat diagonal mirror that redirects the image toward the side of the tube. Because reflecting telescopes have two mirrors, we refer to the objective mirror as the primary, or main, mirror. The diagonal mirror is sometimes called the secondary. The design makes the reflector tops with most beginners.

Glenn F. Chaple, Jr. is a Massachusetts teacher and longtime Astronomy *contributor.*

Did You Know?

The world's largest refracting telescope, located at Yerkes Observatory in Williams Bay, Wisconsin, has an objective lens 40 inches in diameter — an astronomical giant. But compare that to the objective mirrors on some of today's reflecting telescopes, and the giant becomes a midget. The world's largest, the Keck reflector in Hawaii, is a full 10 meters (33 feet) in diameter — that's equal to ten Yerkes lenses laid side by side. It collects one hundred times more light than the Yerkes refractor and equals the light-gathering capacity of 2.7 million human eyes.

TELESCOPE TERMS

ALTAZIMUTH: An inexpensive type of telescope mount that produces up-and-down and side-to-side motions.

APERTURE: The diameter of the objective lens or mirror of a refracting or reflecting telescope.

CATADIOPTRIC: A telescope design that combines the characteristics of both reflecting and refracting telescopes.

CLOCK DRIVE: An accessory found on some equatorial mounts that lets a telescope track sky objects as Earth rotates.

DOBSONIAN: A simple modification of the altazimuth mount.

EQUATORIAL: A type of telescope mount that allows the telescope to track sky objects with one sweeping motion.

EYEPIECE: The part of a telescope's optics that enlarges the image.

FINDERSCOPE: A miniature telescope mounted parallel to the main telescope tube that aids in locating sky objects.

FOCAL LENGTH: The distance between the objective lens or mirror and the image it forms.

OBJECTIVE: The light-gathering lens or mirror in a telescope that forms the image.

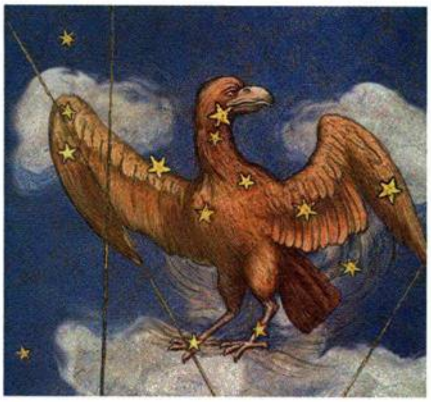
PRIMARY MIRROR: The objective mirror of a reflecting telescope; gathers incoming light and forms an image.

REFLECTOR: A type of telescope that uses a concave mirror to collect light and form an image.

REFRACTOR: A type of telescope that uses a convex lens to collect light and form an image.

SECONDARY MIRROR: A small mirror that redirects the image to the eyepiece.

SCULPTOR, GRUS, AND PHOENIX



Astronomy: Kellie Jaeger

Many of the finest nearby galaxies lie tucked away in the southern constellation Sculptor.

by Tom Polakis

During autumn evenings, while the heart of the Milky Way sets in the southwest, the northern reaches command our attention. This often leaves the area away from the galaxy's plane ignored. While the southerly autumn sky is sparse, it is by no means devoid of interesting targets. These include galaxy groups, nearby galaxies, and a couple nearby deep-sky objects you wouldn't expect to find so far from the Milky Way's glowing band.

As viewed from the lower tier of states, Grus the Crane looks like an inverted "y" of mostly 3rd- and 4th-magnitude stars riding along the southern horizon. Its two brightest stars, Alpha (α) and Beta (β) Gruis, are 2nd-magnitude gems, the latter looking distinctly orange. Northwest of Beta Gruis lie Delta^1 (δ^1) and Delta^2 (δ^2) Gruis, a pleasing naked-eye pair of 4th-magnitude stars separated by a quarter degree. Phoenix is a nondescript grouping of 4th-magnitude stars spread over a wide swath of sky capped by 2.4-magnitude Alpha Phoenicis, a yellow spectral type K star 77 light-years away. The area around Sculptor is the most star poor in the sky, making it weakly defined. Although Sculptor encompasses 475 square degrees, its brightest star glows at magnitude 4.3.

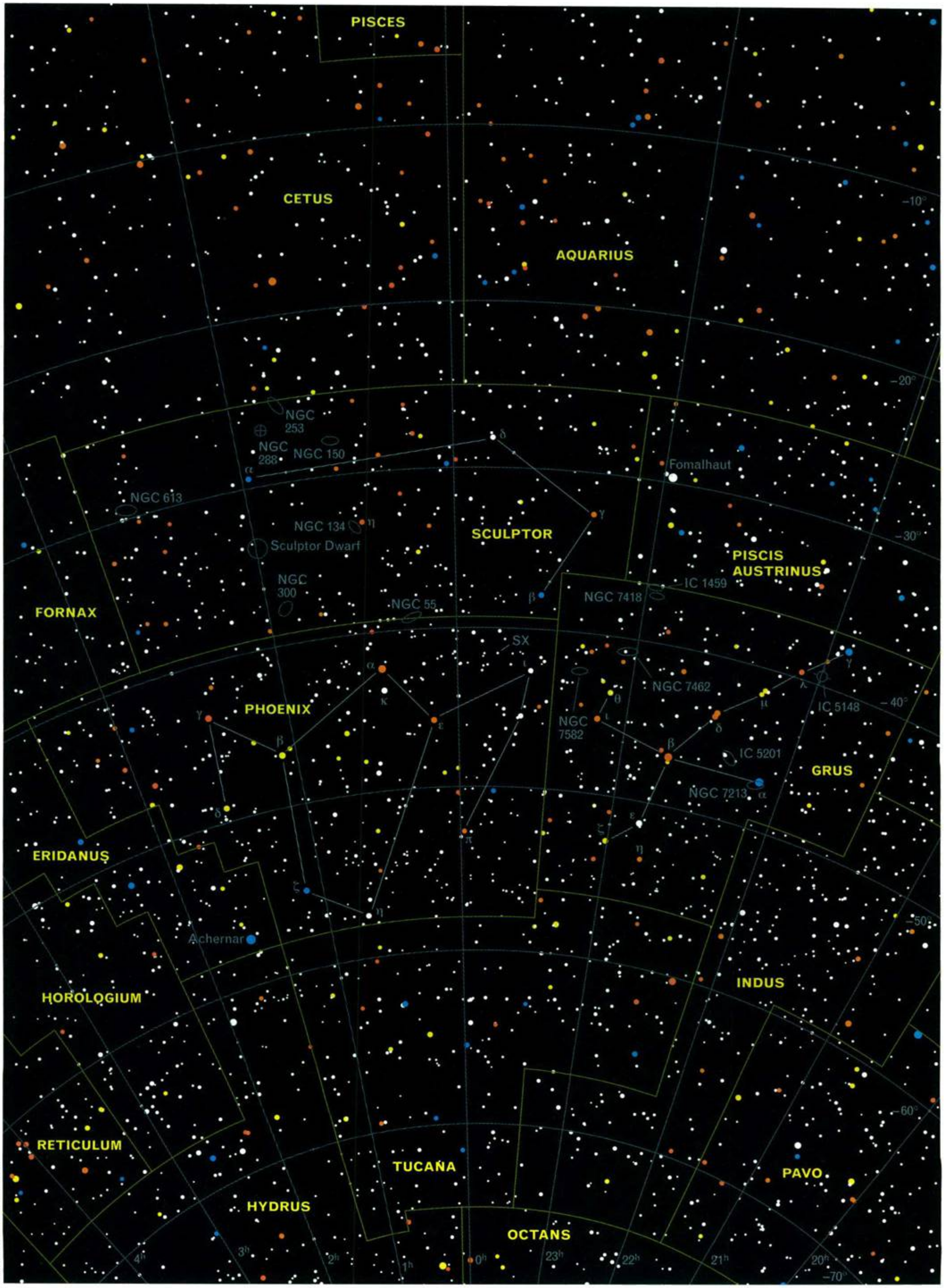
It comes as a surprise to many that a constellation as sparse as Grus is graced by the large planetary nebula **IC 5148**. Find it by panning just over 2° southeast of Gamma (γ) Gruis. Use low power and a narrow-band nebula filter to see its 2' disk, which is brought out faintly with an 8-inch scope. Larger mirrors reveal that the planetary is a thick ring. A very faint central star is visible in an unfiltered view at high magnifications.

NGC 7213 is found in the same telescopic field with Alpha Gruis. In fact, there's no getting rid of the glare from the star. The galaxy is bright and sports a prominent core. Its round form measures 3' through the eyepiece. NGC 7213 is the primary galaxy in a group of nine at the same distance that includes NGC 7232 and NGC 7233 to the northeast. A little over 2° east-northeast of NGC 7213 is the barred spiral galaxy **IC 5201**. The bar of this faint galaxy is visible under good conditions with a 10-inch scope. In addition to the bar, look for a faint knot on the southwest end of the halo. A supernova discovered in this galaxy in 1978 reached 13th magnitude. IC 5201 is 90 million light-years away.

NGC 7582 is the best starting point for viewing the Grus Quartet, a physically associated group of galaxies 70 million light-years away. It has a bright core and an oval halo extending to 4' in length. Only 10' northeast are Quartet members NGC 7590 and NGC 7599. They have similar sizes and shapes but are slightly fainter than NGC 7582. Both NGC 7590 and NGC 7599 are Seyfert 2 galaxies and display bright cores. Rounding out the Grus Quartet is NGC 7552, a half degree to the southwest. Of the four galaxies, it shows the most detail in the form of two lobes symmetrically placed to the east and west of the center. Find **NGC 7462** by projecting a line from Iota (ι) through Theta (θ) Gruis. An 8-inch scope shows it as a bright, thin spindle 3' long. The central area is slightly enhanced, but the galaxy does not have a central bulge.

NGC 253

Jason Ware


PISCES
CETUS
AQUARIUS
-10°
-20°
NGC 253
NGC 288
NGC 150
α
δ
Fomalhaut
NGC 613
NGC 134
η
Sculptor Dwarf
SCULPTOR
γ
-30°
PISCIS AUSTRINUS
NGC 300
NGC 55
β
NGC 7418
IC 1459
FORNAX
SX
α
ι
NGC 7462
γ
κ
PHOENIX
γ
β
ε
NGC 7582
θ
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λ
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IC 5148
-40°
β
IC 5201
GRUS
NGC 7213
α
δ
ε
ζ
π
η
ERIDANUS
ζ
η
Achernar
-50°
INDUS
HOROLOGIUM
-60°
RETICULUM
TUCANA
PAVO
HYDRUS
OCTANS
4h
3h
2h
1h
0h
23h
22h
21h
20h
-70°

Astronomy: Elisabeth Rowan

In the northern reaches of Grus is another galaxy-rich area highlighted by **NGC 7418**. This barred spiral is an oval glow in a 10-inch telescope with a nearly stellar core. Some mottling here suggests spiral structure. From NGC 7418, it's only a 1° pan to the north to the bright elliptical galaxy **IC 1459**. A 6-inch telescope is large enough to show a circular halo surrounding a luminous middle. Larger apertures are needed to reveal an oval shape. To professional astronomers, IC 1459 presents the clearest example of a core that rotates opposite from the outer regions. The favored theory involves a merging event with another galaxy that occurred in the distant past. The distance to the galaxy is 100 million light-years.

NGC 300

Martin C. Germano

SX Phoenicis is the prototype of a class of variable stars with extremely short periods. This star varies between magnitudes 6.7 and 7.5 over a period of only 80 minutes. Observers should be able to notice a change in brightness in under a half hour. About 4° northeast of Alpha Phoenicis is the spectacular galaxy **NGC 55**, the Cigar Galaxy. It is the most luminous member of the Sculptor group of galaxies. It's also the nearest, at a distance of less than 5 million light-years. These numbers result in a galaxy that shows detail readily. It's easy to spot in 7x50 binoculars, but the rewarding views come through the scope. Using a 13-inch telescope, it appears nearly 30' long with the brightest area offset west of center. The face of NGC 55 changes markedly with a nebula filter in place, as three HII regions come to life. The easternmost of these is distinctly nonstellar.

Another nearby Sculptor Group galaxy is **NGC 300**, the Southern Pinwheel Galaxy. Physically similar to the northern sky's true Pinwheel, M33, an 8-inch telescope shows NGC 300 to be a second cousin. It exhibits low surface brightness and a broadly concentrated core over an area 6' by 4'. Upping the aperture to 16 inches shows the spiral arms as mottling

Deep-Sky Objects in Sculptor, Grus, and Phoenix

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep./Per.	Type	Notes
NGC 55	0h14.9m	–39° 11'	8.1	30.0' by 6.3'	Gal	SB(s)m
NGC 134	0h30.4m	–33° 15'	10.4	8.5' by 1.9'	Gal	SB(s)bc
NGC 150	0h34.3m	–27° 48'	11.3	3.4' by 1.6'	Gal	SA(s)c
NGC 253	0h47.6m	–25° 17'	7.6	30.0' by 6.9'	Gal	SAB(s)c
NGC 288	0h52.8m	–26° 35'	8.1	13.8'	GC	
NGC 300	0h54.9m	–37° 41'	8.1	20.0' by 13.0'	Gal	SA(s)cd
Sculptor Dwarf	0h59.9m	–33° 42'	8.8	1.1° by 0.8°	Gal	SB(s)cd
NGC 613	1h34.3m	–29° 25'	10.1	5.5' by 4.1'	Gal	SB(rs)bc
IC 5148	21h59.5m	–39° 23'	11	120"	PN	
NGC 7213	22h09.3m	–47° 10'	10.0	4.8' by 4.2'	Gal	SA(rs)0
IC 5201	22h21.4m	–46° 04'	11.0	6.6' by 4.4'	Gal	SB(s)dm
NGC 7418	22h56.6m	–37° 02'	11.0	4.2' by 2.1'	Gal	SB(rs)c
IC 1459	22h57.2m	–36° 28'	10.0	4.9' by 3.6'	Gal	E2
NGC 7462	23h02.8m	–40° 50'	11.3	5.1' by 0.8'	Gal	Sb
NGC 7582	23h18.4m	–42° 22'	10.1	6.9' by 2.6'	Gal	SB(s)a
SX Phe	23h46.5m	–41° 34'	6.8/7.5	80 min.	Var	

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep./Per.:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble type for galaxies or type for variable stars.

The Phoenix

". . . Down thither, prone in flight
He speeds, and through the vast ethereal sky
Of towering eagles, to all the fowls he seems
A Phoenix, gazed by all; as that sole bird."
Paradise Lost
John Milton (1608–1674)

While stories of ancient royalty, fearsome monsters, and exalted heroes play out on the mythological canvas of the northern sky, the tales of the southern sky paint a far different picture. Here we find the people, animals, and instruments that fired the imaginations of scientists and explorers in the 16th through 18th centuries.

Sculptor the Sculptor dates from 1754, when the French astronomer Nicolas Louis de Lacaille presented a map of the southern sky depicting 14 new constellations he had invented. Of the 88 constellations now recognized, Lacaille's 14 were the last to be introduced.

Grus the Crane and Phoenix the Phoenix originated more than a century and a half earlier. At the end of the 16th century, Dutch navigators Pieter Dirkszoon Keyser and Frederick de Houtman introduced a dozen new constellations near the South Celestial Pole. Grus and Phoenix joined with Apus the Bird of Paradise, Pavo the Peacock, and Tucana the Toucan to create a celestial aviary that dominates the southern spring sky.

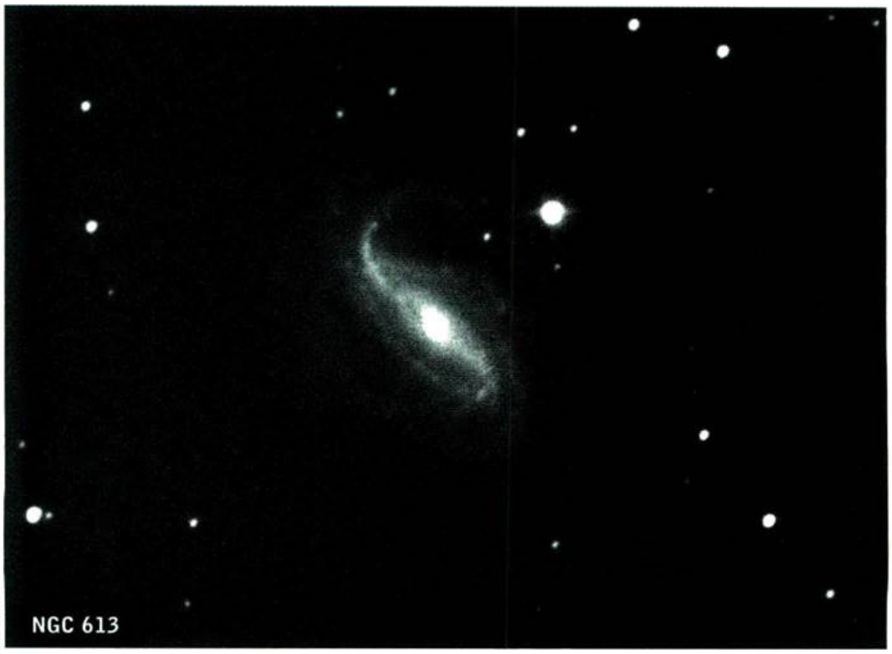
The legendary phoenix was as large as an eagle, with brilliant crimson and gold plumage and a beautiful song. Although only one phoenix existed at a time, it managed to keep itself off the endangered-species list. When the bird felt death approaching (after a healthy life span of 500 years or more), it built a nest of cinnamon bark and other spices and set it ablaze. After the old phoenix was consumed by the flames, a new one arose from the ashes. Once the baby bird grew up, he carried the nest to Heliopolis (the city of the sun) in Egypt and deposited it in the temple of the sun-god, Ra. — *Richard Talcott*

around the periphery. Again a nebula filter can be used on this galaxy to enhance the appearance of HII regions, but the effect here is more subtle than with NGC 55. The distance to NGC 300 is 7 million light-years.

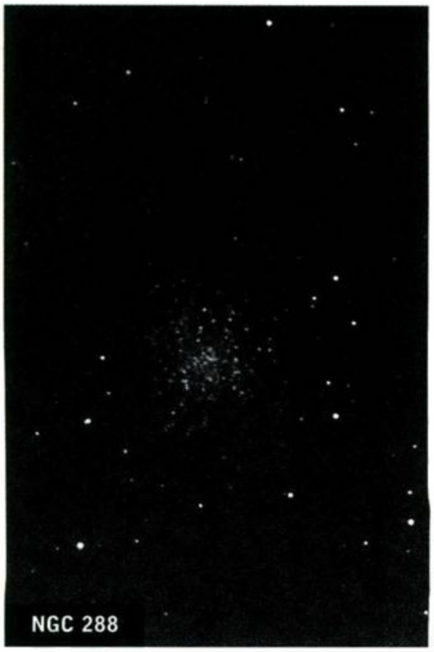
NGC 134 can be found a half degree east-southeast of the 5th-magnitude star Eta (η) Sculptoris. This bright galaxy is viewed nearly edge-on and appears almost 6' long through the telescope. It has a bright, sharp core surrounded by some mottled detail. This would be a pretty ordinary view of a galaxy if not for the enhancement by the presence of NGC 131 only 9' to the west. While it is much fainter and smaller than NGC 134, it shares the same position angle, creating a pleasing visual effect. The two galaxies are about 70 million light-years away.

NGC 150 appears as a tiny, but bright, galaxy. Even in large telescopes it appears only 2' across but shows detail of distorted spiral arms to the north and south of the core. A supernova in NGC 150 discovered by Robert Evans in Australia reached 14th magnitude. At a distance of 60 million light-years, this anomalous supernova was more than 2 magnitudes brighter than expected for a "standard candle."

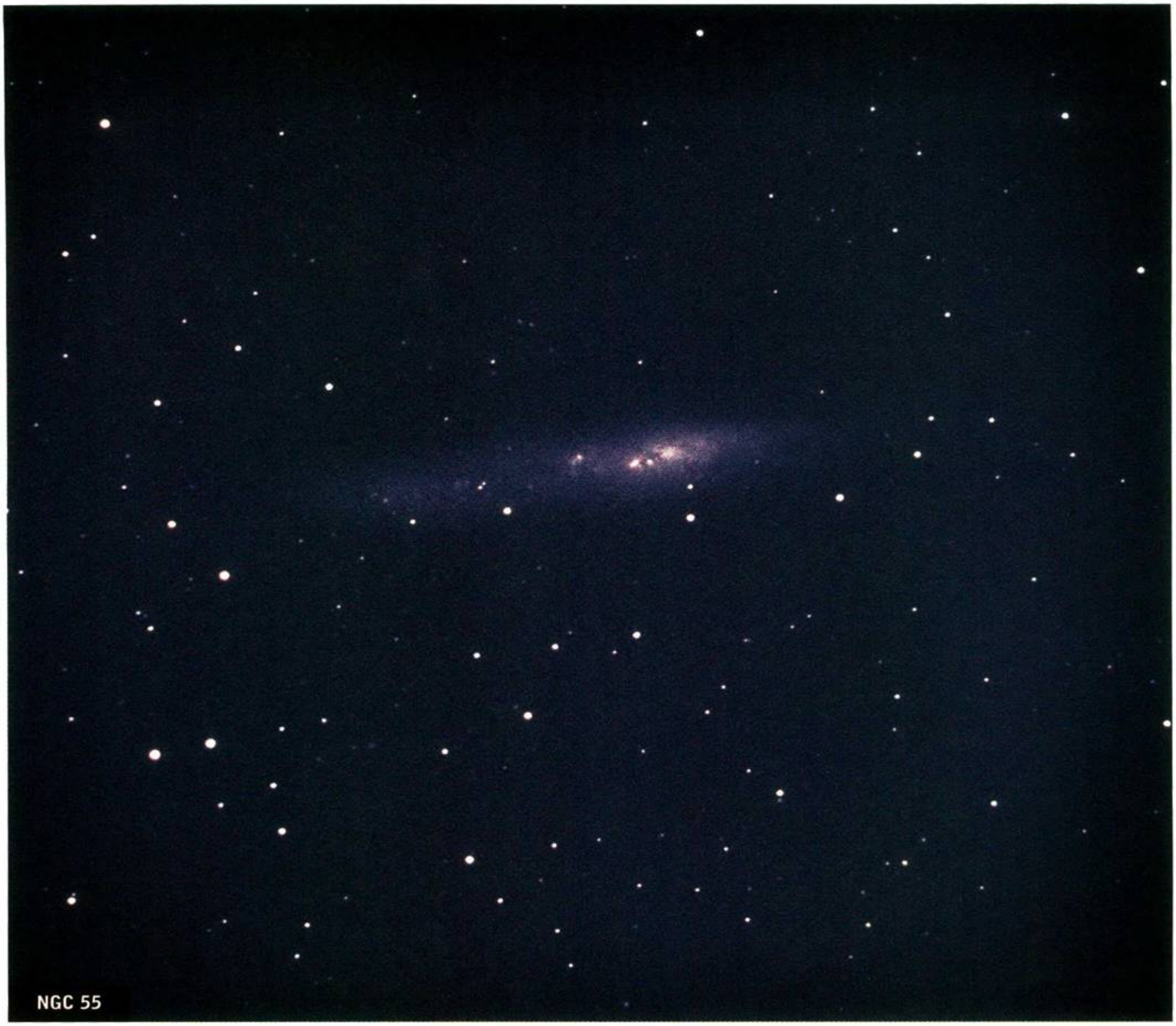
The showpiece deep-sky object of the entire southern autumn sky is **NGC 253**. At 8 million light-years it is the nearest example of a large spiral


NGC 613

Preston Scott Justis


NGC 288

Thomas L. Dessert



Joe Liddell

galaxy outside of the Local Group. It stands out well with the slightest optical aid and may be visible to the keenest-eyed observers with the naked eye. At 50x in a 6 inch, it appears about 20' long and 5' wide. Through a 10 inch the galaxy appears remarkably mottled. The core is only slightly brighter than its surroundings but well defined. Out from the center you can see a number of dark lanes and vague hints of spiral structure. Use as high magnifications as the seeing will allow on this bright galaxy.

The unlikely spectacle of a globular cluster shows up about 2° southeast of NGC 253. **NGC 288** lies less than 1° from the South Galactic Pole, which results in a view nearly unaffected by absorbing clouds of dust. The cluster is 30 million light-years away, so its brightest stars resolve well in medium-aperture instruments. The apparent size through a telescope comes in at less than half its cataloged size of 14'. About 50 14th-magnitude stars shine across a core that shows little concentration. In small telescopes, NGC 288 appears much like a distant comet.

The Sculptor Dwarf was discovered in 1937 by Harlow Shapley and is notable as the first known dwarf elliptical galaxy in the Local Group. At a distance of only 250,000 light-years, this is a rare example of a galaxy whose proper motion can be measured. The proper motion studies showed that the Sculptor Dwarf is not moving in the same orbit as the Magellanic Clouds. The Sculptor Dwarf is aptly named; the Milky Way is 50,000 times as massive and 10,000 times as luminous.

Some ambitious observers have attempted to get a view of the Sculptor Dwarf. The most successful amateurs have used rich-field telescopes in the 6-inch to 8-inch class capable of taking in its full size, which is more than 1° across. Under dark and transparent skies, one can expect to see no more than a very diffuse haze that's just brighter than its surroundings.

We conclude with the barred spiral galaxy **NGC 613**. It is bright, four times as long as its width, and shows a prominent central concentration. On the best nights a slightly brighter portion shows up on the eastern end. This is the beginning of one of the spiral arms, which elude all but the largest apertures. A

Tom Polakis is an aerospace engineer who lives in Tempe, Arizona, and enjoys viewing galaxies and nebulae.

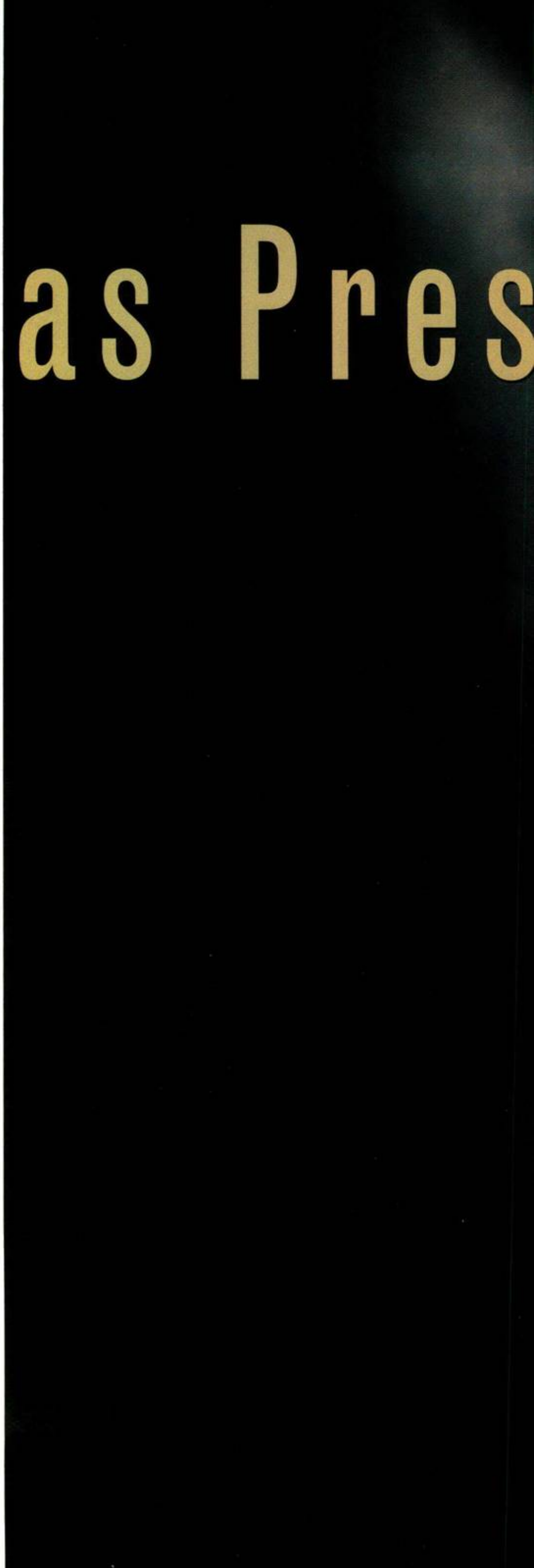
Christmas Pres

Whether they've been good or bad, North Americans can count on at least one astronomical present this Christmas.

by Richard Talcott

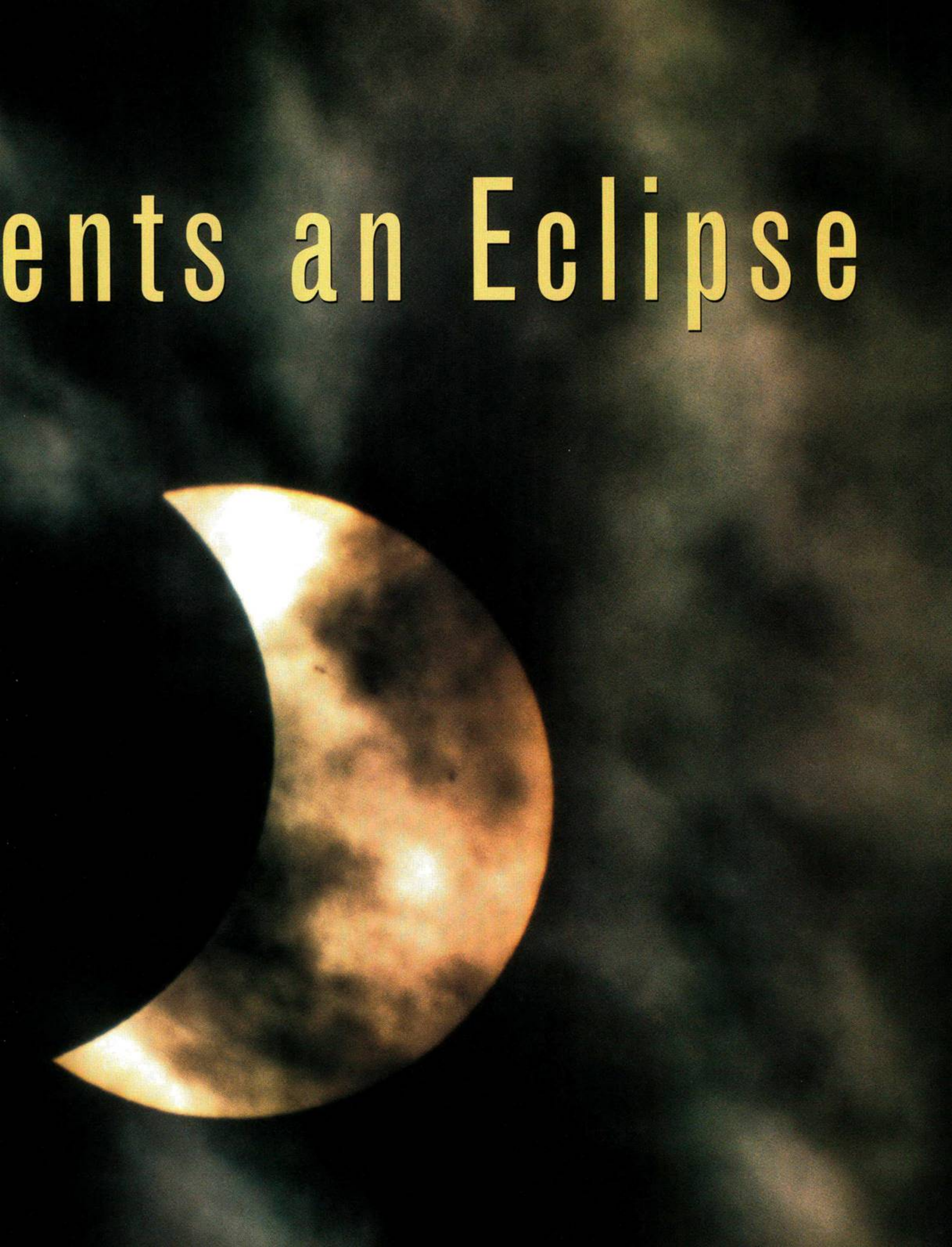
This year Santa Claus comes bearing gifts for children of all ages. On Christmas Day, December 25, Santa steers the moon in front of the sun, bringing a partial solar eclipse to nearly everyone in North America.

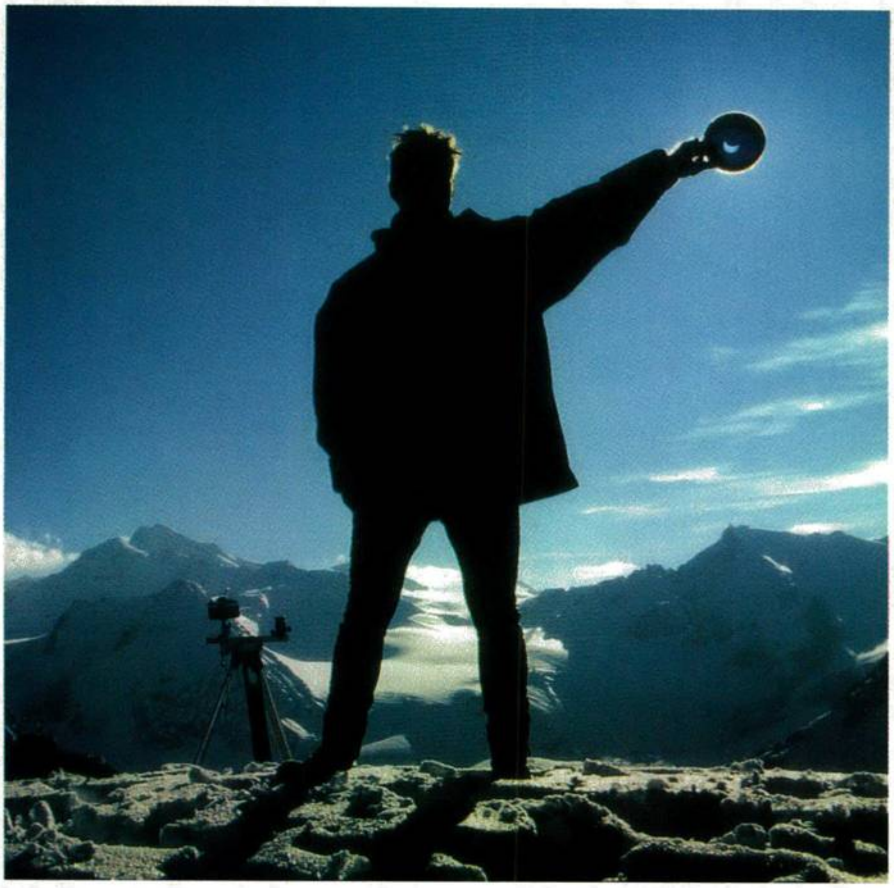
The eclipse action starts along the West Coast, where, for many people, the sun rises in partial eclipse. The farther east you live, the later the moon's shadow arrives. Likewise, the



Slight cloud cover adds drama to this partial eclipse. William Hood

ents an Eclipse





Left: Bernd Liebscher holds a solar filter at 3,000 meters on The Pitztaler Jöchl at Sölden, Austria. Harald Liederer & Bernd Liebscher
Above: A flock of birds reacts to an eclipsing sun in Jordan. Hani Dalee & Iyad M. Ahmed
Below: A 3-inch refracting telescope projected this eclipse image in downtown Baltimore, Maryland. Herman M. Heyn & John Strohsacker

farther north and east you live, the more the moon covers the sun. But nowhere on Earth will anyone see a total eclipse this Christmas. Instead, because of the geometry of Earth's orbit, the totality part of the moon's shadow bypasses our planet completely and disappears into space.

So there'll be no pearly white corona, no flaming prominences, no ring of twilight around the horizon. The joys of viewing a partial eclipse are more subtle. And the fact that the moon's shadow will embrace an entire continent isn't something to dismiss.

The SUN (our star)

In Mexico and northern Central America, less than 20 percent of the sun will be hidden from view. All the big cities in the northeastern United States will see more than 50 percent coverage. Yet from a meteorological standpoint, the timing of this partial eclipse is not the best. Much of North America experiences the cloudiest month of the year in December. For residents along the East Coast or near the Great Lakes, the chances of clear skies run less than 50 percent. However, climate statistics only tell you what to expect — weather does what it wants.

Greatest eclipse occurs in northern Canada on Baffin Island, where 72 percent of the sun will disappear. Use the map and table on this page to estimate eclipse circumstances at your location.

This Christmas gift won't be a pleasant one, however, if you don't make an effort to protect your eyes. Two factors make viewing a partial eclipse dangerous: The eclipse makes you want to look at the sun, and it's easier to gaze at the sun for a long period because the amount of light coming from it is less.

The human eye acts like a lens, focusing incoming sunlight onto the retina. If you've ever used a magnifying glass to focus sunlight on a piece of paper, you've seen how easily the sun can burn. The same thing happens when you look at the sun, except it's the delicate tissue of your retina that burns. Damage to the unaided eye occurs in as little as 30 seconds. With binoculars or a telescope, the damage happens in a fraction of a second. Because the retina has no pain receptors, there's no warning that you've injured your eyes, and the visual effects may not show up until hours later.

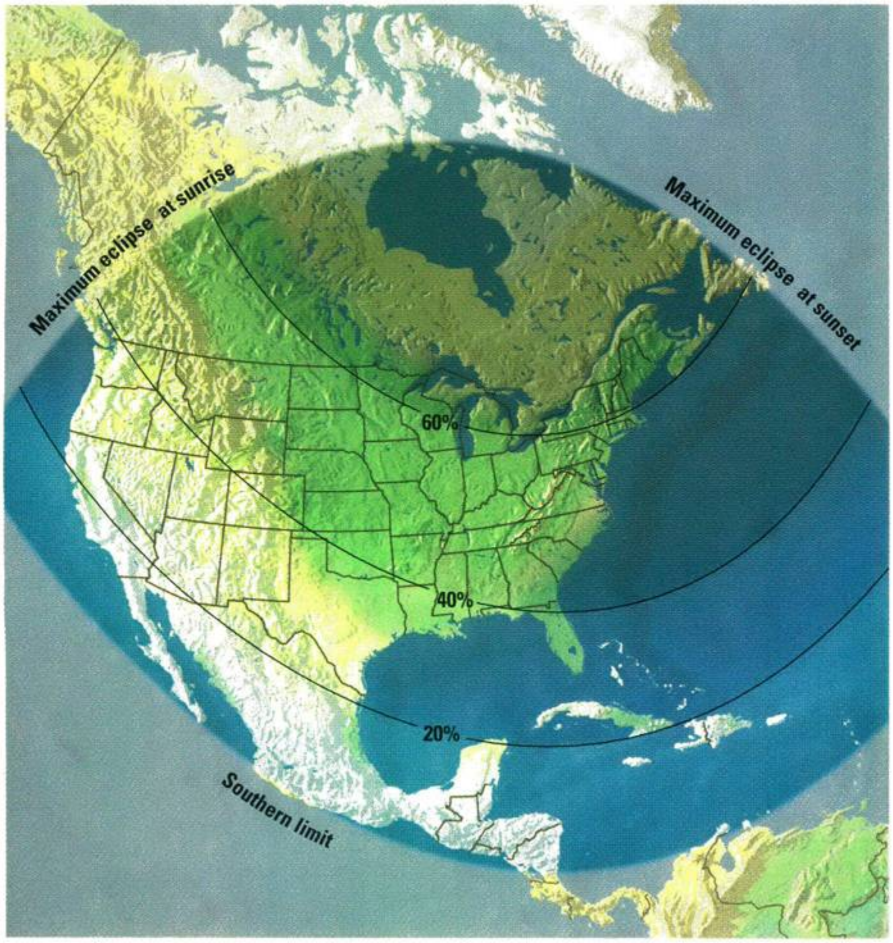
Fortunately, there are ways to enjoy a partial eclipse without risking your eyesight. The simplest way is to view the sun indirectly by projecting its image. You can make a simple pinhole viewer out of two pieces of stiff white cardboard and a piece of aluminum foil. Cut a square hole in one piece of cardboard, then tape the aluminum foil over the hole. Next take a straight pin and poke a small hole in the center of the foil. To view the eclipse, let the sun's light pass through the pinhole and onto the second piece of cardboard, which serves as a screen. Stand with your back to the sun as you view the screen.

You can watch a partial eclipse directly through a high-quality filter. An inexpensive filter is a #14 arc-welder's glass, which blocks all the sun's infrared and ultraviolet radiation and slashes visible light by a factor of 370,000. (If you choose this option, make sure to get a #14 glass — those with lower numbers don't filter out

ECLIPSE TIMETABLE

		Maximum eclipse		
City	Eclipse Begins	Time	Altitude	Magnitude
Atlanta	10:53 A.M.	12:25 P.M.	33°	45%
Boston	11:15 A.M.	12:52 P.M.	22°	58%
Chicago	9:45 A.M.	11:17 A.M.	24°	55%
Cleveland	10:54 A.M.	12:30 P.M.	25°	56%
Dallas	9:38 A.M.	10:57 A.M.	30°	35%
Denver	8:29 A.M.	9:44 A.M.	19°	40%
Detroit	10:52 A.M.	12:27 P.M.	24°	57%
Edmonton	sunrise	9:44 A.M.	5°	53%
El Paso	8:36 A.M.	9:38 A.M.	25°	24%
Houston	9:43 A.M.	11:00 A.M.	33°	31%
Indianapolis	10:47 A.M.	12:20 P.M.	27°	53%
Jacksonville	11:01 A.M.	12:33 P.M.	36°	40%
Los Angeles	7:37 A.M.	8:23 A.M.	14°	15%
Memphis	9:43 A.M.	11:12 A.M.	30°	44%
Miami	11:12 A.M.	12:38 P.M.	41°	32%
Minneapolis	9:38 A.M.	11:06 A.M.	20°	56%
Montreal	11:09 A.M.	12:46 P.M.	20°	61%
New Orleans	9:48 A.M.	11:12 A.M.	35°	35%
New York	11:09 A.M.	12:47 P.M.	25°	56%
Phoenix	8:35 A.M.	9:30 A.M.	19°	21%
St. Louis	9:42 A.M.	11:11 A.M.	27°	49%
San Francisco	7:33 A.M.	8:21 A.M.	9°	19%
Seattle	sunrise	8:29 A.M.	4°	37%
Toronto	10:58 A.M.	12:34 P.M.	23°	59%
Vancouver	sunrise	8:31 A.M.	2°	39%
Washington, D.C.	11:04 A.M.	12:41 P.M.	27°	54%

All times are local time



enough light.) A good place to buy arc-welder's glass is at welding supply stores, which are normally listed in the phone directory under "Welding Equipment and Supplies."

Alternatively, you can use either a Mylar filter or a metal-on-glass filter. Mylar filters allow more blue light than red light to pass through, so they make the sun appear a cool blue-white color. Metal-on-glass filters, on the other hand, yield a yellow-orange sun. Look for suppliers of these filters in advertisements in *Astronomy*.

Knowing what filters are unsafe is just as important. Never use a so-called "sun filter" that screws on the bottom of a telescope's eyepiece. These filters, which come with some inexpensive, imported telescopes, can crack when in use and let through the full power of the sun's light. Viewers must also avoid using exposed color or black-and-white film, sunglasses, smoked glass, polarizing filters, or photographic neutral density filters. While all these materials limit the amount of visible light that passes through, they do almost nothing to stop the equally dangerous infrared radiation.

Astronomy's January 2001 issue will include a free pair of eclipse glasses for safe viewing on Christmas Day. This issue should be available the first week of December.

People near the fringes of the shadow may see only a small bite taken from the sun. When the moon covers about half of the sun, perceptive eyes will start to notice changes. Watch for shadows to become sharper as the source of light grows smaller. Also look closely at the shadows caused by sunlight filtering through the leaves of trees and bushes. The foliage openings serve as pinholes and project images of the eclipsed sun. Expect to see hundreds or even thousands of tiny crescent suns.

Visual treats offered by this partial eclipse may not dazzle, but will still offer fascinating examples of what happens when worlds align — and partial eclipses are far easier to come by. Perhaps this Christmas eclipse will just whet our appetites for exploring totality the next time it touches down in Africa this coming June. ■

Associate editor Richard Talcott chases eclipses whenever he can and expects to see totality in Africa next June.

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Just the right size for younger stargazers, and incredibly easy to master! Adults will love it too, for its portability and crisp optical performance.
Steel tube, 114mm mirror (f.l. 910mm, f/8), 1.25" R&P focuser, 6x30 achromatic finder scope, 25mm (36x) and 9mm (110x) Plössl eyepieces (1.25"), 5" flanged altitude hubs, CorrecTension Friction Optimization, built-in handle, dust cap. Weight: tube 9 lbs., base 8-1/2 lbs.

$199

SkyQuest XT6
The overachieving XT6 will show Jupiter's Red Spot, Saturn's Cassini Division, hundreds of clusters and nebulas, and galaxies tens of millions of light-years distant. Nicely portable and very affordable!
Steel tube, 152mm parabolic mirror (f.l. 1200mm, f/8), 1.25" aluminum R&P focuser, 6x30 achromatic finder scope, 25mm (48x) and 9mm (133x) Plössl eyepieces (1.25"), Moon filter, eyepiece rack, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap. Weight: tube 13 lbs., base 24 lbs.

$369

SkyQuest XT8
The XT8's prodigious performance on both solar system and deep-sky denizens have made it the telescope of choice for thousands of astronomers, from beginners to die-hard hobbyists.
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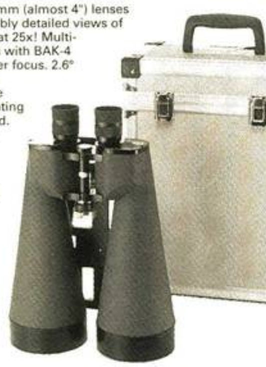

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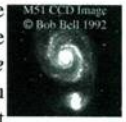
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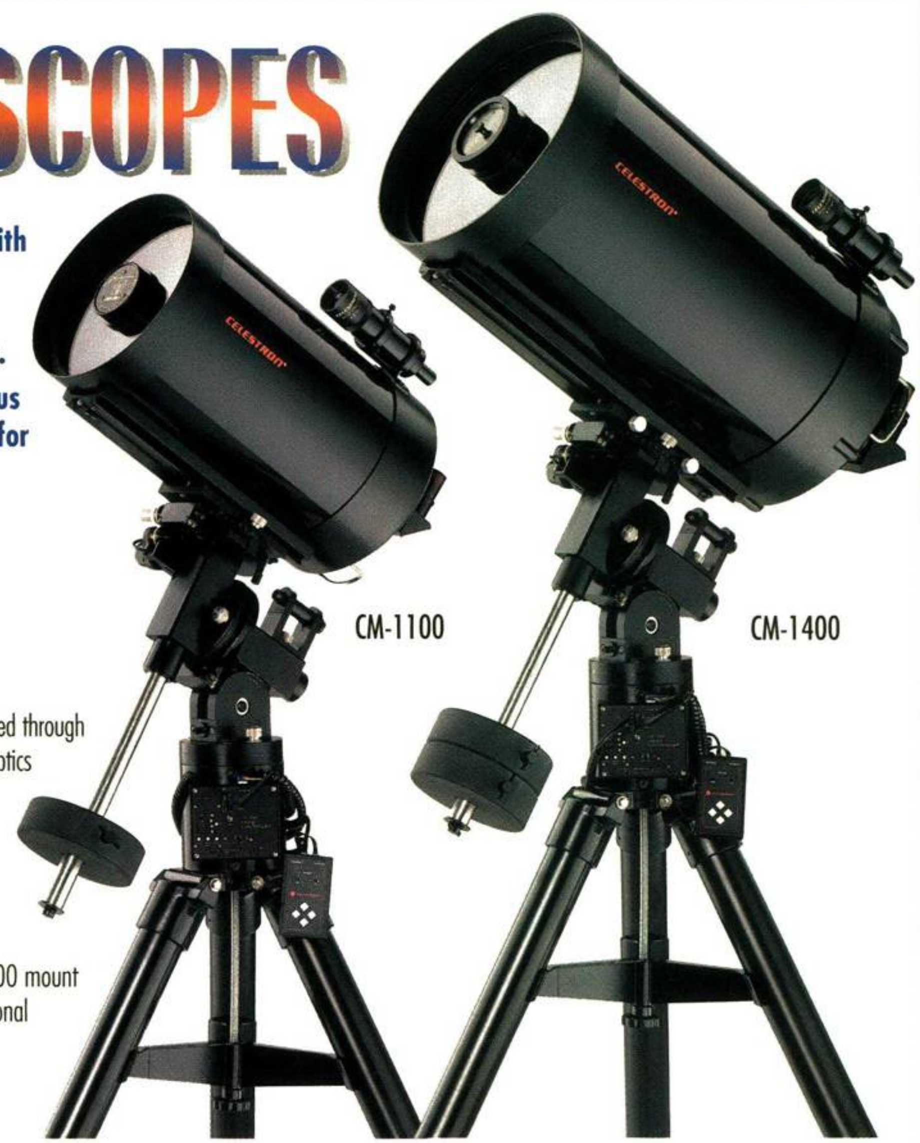

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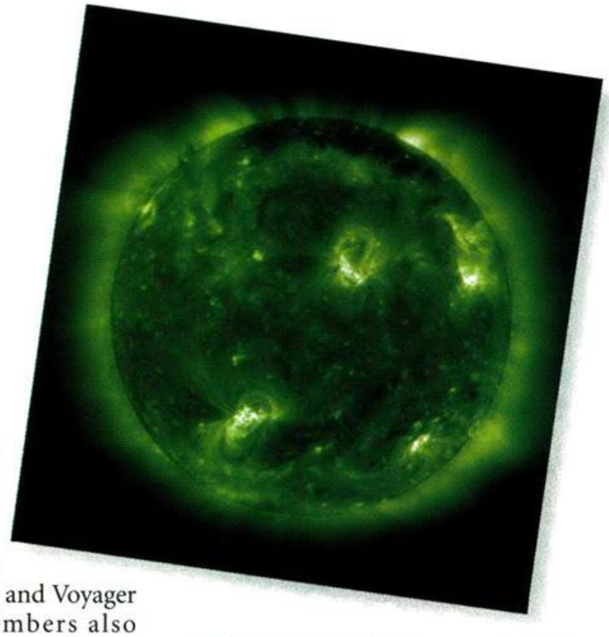
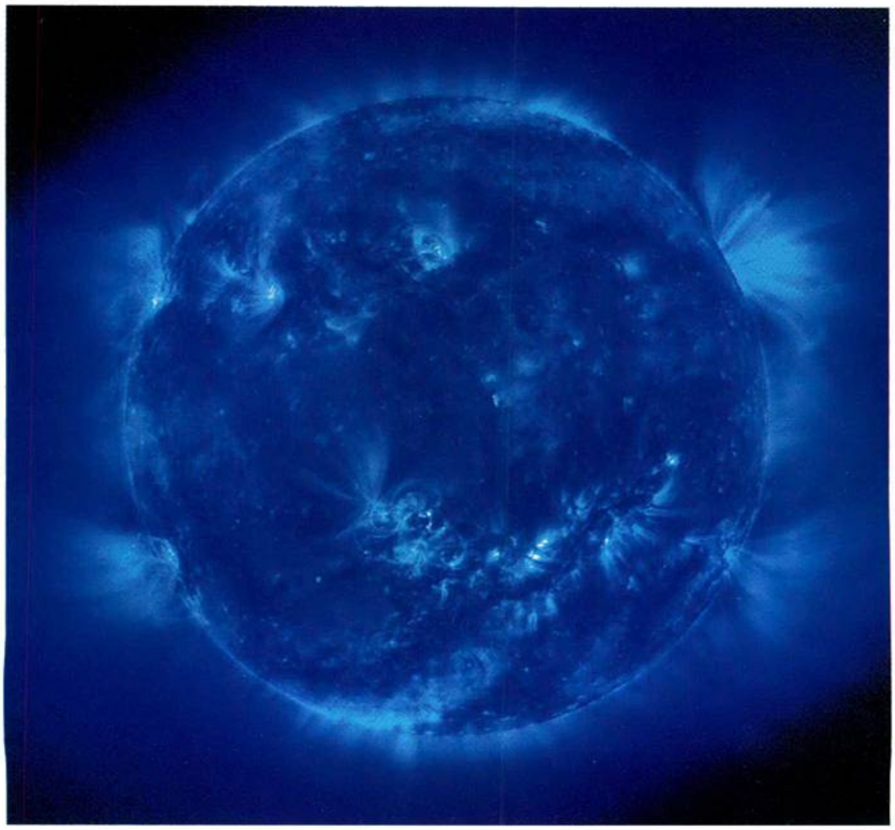


Our galaxy's dark-matter halo causes stars far from the nucleus to orbit faster than they normally would. Why doesn't the same effect take place in the solar system? Shouldn't all the planets be zipping along at roughly the same speed as Mercury? — *Sean Donnelly, Ottawa, Ontario*

This is a question I've often wondered about myself. It turns out that whatever dark matter is, there's not much of it in the solar system.

In the mid-1990s, a team of astronomers at the Jet Propulsion Laboratory, the University of Texas at Austin, and Southern Methodist University analyzed the trajectories of the Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2 spacecraft. Team members also refined the masses of Uranus and Neptune to very high precision. Their detailed analyses provided an upper limit on the amount of dark matter orbiting the sun. There's less than one Earth mass of dark matter inside the orbit of Neptune and less than one-sixth of an Earth mass inside Uranus's orbit. These are just upper limits; the real amount is probably tiny. And because this material is widely and evenly dispersed, it has a negligible effect on the motions of the planets.

But if you take this relatively low density and expand it over the gargantuan volume of space in the galactic halo, then it amounts to an enormous mass. In fact, dark matter exerts a gravitational force about 10 times greater than all the stars and gas in our galaxy combined. In other words, dark matter has little effect on small scales, but it flexes its muscles on the scale of galaxies and clusters of galaxies. — *Robert Naeye, senior editor*

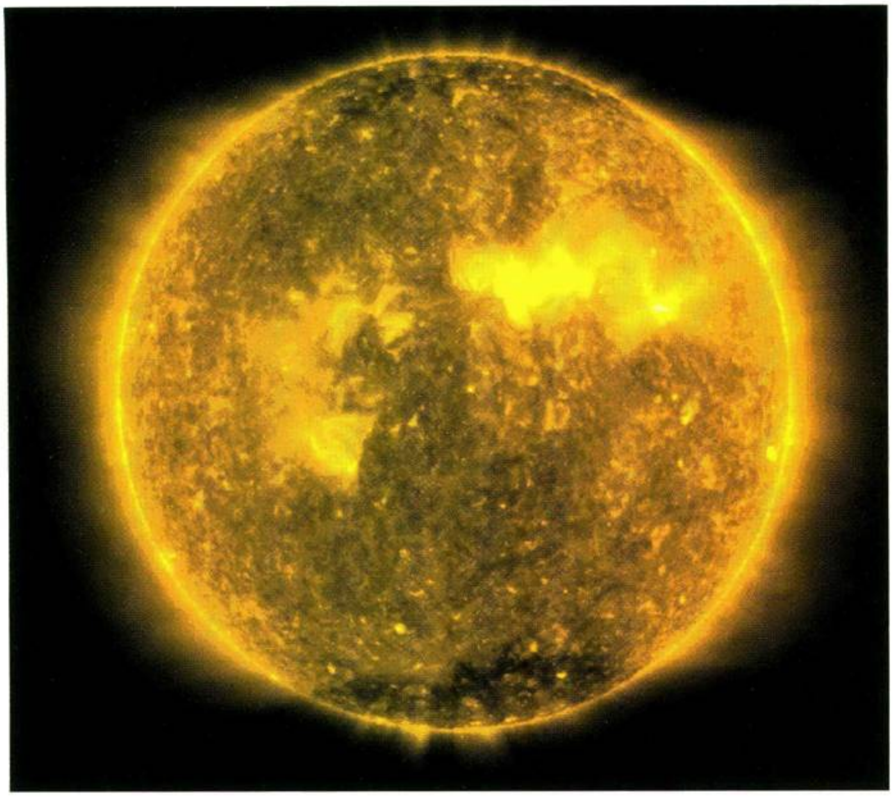


I've read conflicting statements about the color of the sun. What is the sun's true color? — *Ray Montello, Seabrook, Texas*

Much has been written about the true colors of the sun and stars. The true colors are those you see. No one else matters.

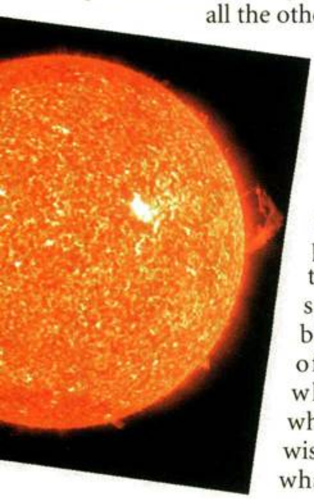
We all seem to see color somewhat differently. I see Vega as blue-white, not white as is so often stated. I see Arcturus as quite orange (I recall being amazed by the color as a child), yet some would say I am wrong, that I really see it as yellow. Well, no, it appears orange to me, and Betelgeuse is noticeably red, thank you.

All stars emit radiation across the optical spectrum, from red to blue. The color you see depends on the



distribution of that light and the effect that the combination of colors has on your eyes. A cool star such as Betelgeuse emits very little blue light, and so it appears reddish. The sun's radiation peaks at a wavelength around 5000 angstroms, in the green part of the spectrum. But the sun does not appear green because the green is mixed with all the other colors.

To me, a shaft of sun looks yellow-white (never look directly at the sun), and indeed that is in part a product of the atmosphere's scattering of the blue component of sunlight. But what I see is not what someone else wishes me to see or what I might see in space (where I am not). If someone else sees sunlight as white, yellow, orange, or purple, that's fine. I will not argue. — *Jim Kaler, University of Illinois. Visit his Star of the Week on his website at www.astro.uiuc.edu/~kaler/sow/sow.html.*



Scientists assigned arbitrary colors to the sun in these images from SOHO's Extreme ultraviolet Imaging Telescope. Even with the eye, different people might see different colors, but not to this extreme. NASA/ESA/EIT Consortium

Which planet would be the brightest in Mars's night sky: Venus, Earth, or Jupiter? And would Earth's moon be visible to the naked eye? — *John Lindblad, Toronto, Ontario*

This was fun to answer. The brightness of the planets as seen by an observer on Mars depends on a variety of factors. It depends largely on the positions of the planets in their orbits, and whether Mars is near perihelion or aphelion. But it also depends on factors such as the weather on Earth (heavy cloud cover makes Earth brighter because it reflects more sunlight). Overall, Earth is the "star" of Mars's show. At its brightest, Earth reaches a magnitude of about –3.5. Both Jupiter and Venus reach a maximum brightness of about a half magnitude fainter.

And yes, you could see Earth's moon without optical aid if it's in the right position in its orbit. At its maximum separation from Earth, the moon would lie about a third of a degree from Earth. That's a far enough separation that its magnitude 3 glow would not be swamped by Earth's glare. Let's hope that human explorers on Mars will one day enjoy the view! — *Richard Talcott, associate editor*

Could you recommend some books for beginning observers? — *Carl Reynolds, Long Beach, California*

One good book that comes to mind is *Turn Left at Orion*, by Guy Consolmagno and Dan M. Davis. It tells you how to scan not only the planets and our moon over the course of a month, but tour deep-sky targets by season. Each featured object (there are more than 100) is matched up with tabular information, a narrative description, and a drawing of what it looks like through a telescope.

Another good title, *Seeing the Sky*, by Fred Schaaf, presents more than 50 telescopic observing programs broken into chapters about the moon, the sun, planets, comets, asteroids, and meteors. It tells you how to look for geological features in lunar craters, scope out structure in sunspots, follow eclipses of Jupiter's moons, and search for telescopic meteor showers, just to name a few. Tables and illustrations are scattered throughout.

Touring the Universe through Binoculars, by frequent *Astronomy* contributor Philip S. Harrington, discusses low-power views of the moon, the sun, asteroids, and the planets. But the meat of this book is a night-sky survey organized by constellation. Tables and descriptions lay out the brighter and most notable targets within each constellation. Harrington's book *Star Ware* is an excellent guide to telescopes, binoculars, and accessories.

Finally, I'll recommend the *Beginner's Guide to Amateur Astronomy*, by *Astronomy* managing editor David J. Eicher, and *Nightwatch* by Canadian astronomer Terence Dickinson. — *John Shibley, contributing editor* ■

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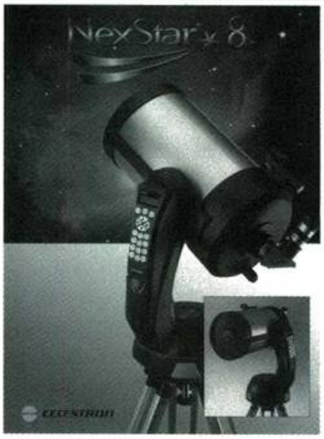

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1.25" Deep Sky Filter (fits most 1.25" eyepieces)	$99.50
48mm Deep Sky Filter (fits 2" eyepieces and Lumicon accessories)	$199.50
Visual Back Deep Sky Filter (fits in series on back threads of SCT'S)	$199.50
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*step rings for other sizes available.

Lumicon Ultra High Contrast Filters have a narrow band pass that lets thru the two oxygen III and the hydrogen beta lines while blocking the remaining visual spectrum. The resulting filter yields high contrast views of all types of nebula. It is best used visually with any telescope of f/6 or longer focal ratio. The Ultra High Contrast Filter is not for photography.

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Lumicon Hydrogen Beta Filters isolate just the hydrogen beta line of the spectrum and block the remaining visual spectrum. The Hydrogen Beta filter was created with a select number of low energy nebula in mind such as the Horsehead, Cocoon & the California nebula. In many instances the Hydrogen Beta filter is the **ONLY** way to see these nebula. The Hydrogen Beta Filter is a visual filter only, best suited to 8" or larger aperture telescopes with focal ratios of f/5 or faster.

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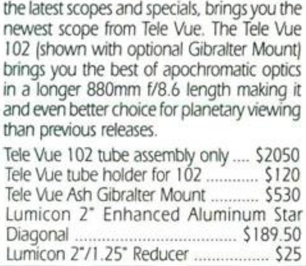

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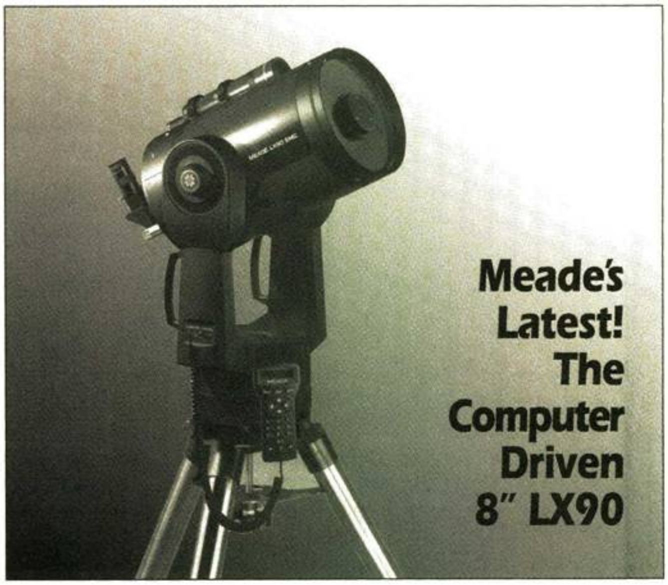

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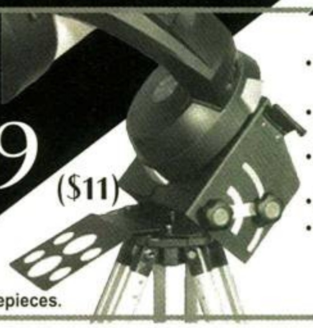

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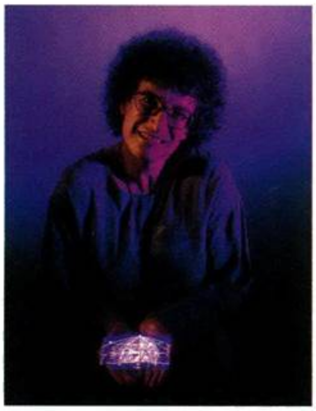

A distinguished researcher has her say.

by John P. Wiley, Jr.

It began when her father showed her a snowflake through a microscope. She was fascinated by the geometry, the six-point symmetry. She became equally intrigued by the explanations her father, a crystallographer at Bell Labs, provided of how the patterns produced by crystals revealed the underlying atomic structure.

As she grew older, she became the designated map reader on family drives. As their car approached an intersection, her father would ask: "OK, which way do I go?" She was expected to have a ready answer.

On a cold, rainy day in Washington last April, that little girl, now a professor at Harvard, gave the first Distinguished Research Lecture in a Smithsonian auditorium. It was all about shapes and the making of maps. Margaret Geller is mapping nothing less than the large-scale structure of the universe. Think of taking a slice through soap bubbles in your sink, she said. Then imagine that the bubbles are not an inch but hundreds of millions of light-years across.

We have known precisely where galaxies are (their right ascension and declination) for a long time. In the 1960s, for example, Fritz Zwicky plotted the positions of 30,000 galaxies in the northern sky. It takes a lot more time to determine their distance, something researchers do by measuring how features in their spectra are shifted toward red by their recessional velocity.

A colleague at Harvard said he had determined that galaxies are not uniformly distributed in space, that in fact there were great voids in which few or no galaxies were to be found. Geller thought he was mistaken. So she and her colleagues began their own survey of galaxies, working on the 1.5-meter telescope at the Smithsonian's observatory on Mt. Hopkins in Arizona. In their first year they measured the distances to only 1,000 galaxies, but that was enough.

She not only saw the voids, she saw the sheets of galaxies that outlined those voids, the fabric of the bubbles. She first saw the now familiar "stick man" formed from lines of coalescing galaxies. Seeing all this was a feeling you never forget, she said; "It was a kind of magic."

Geller's team is now surveying a million galaxies and soon will be using the new 6.5-meter telescope on Mt. Hopkins. (Size does matter, because you need a lot more light-gathering power to be able to spread the light from an object out into a spectrum. The Hubble telescope, for example, is wonderful at what it does but not of much value for spectrographic work. It is, after all, on the smallish side.)

At one point in her lecture, Geller showed a painting by Jasper Johns. To one viewer, at least, it seemed to be a scene inside a house under very coarse construction, with inexplicable outlines

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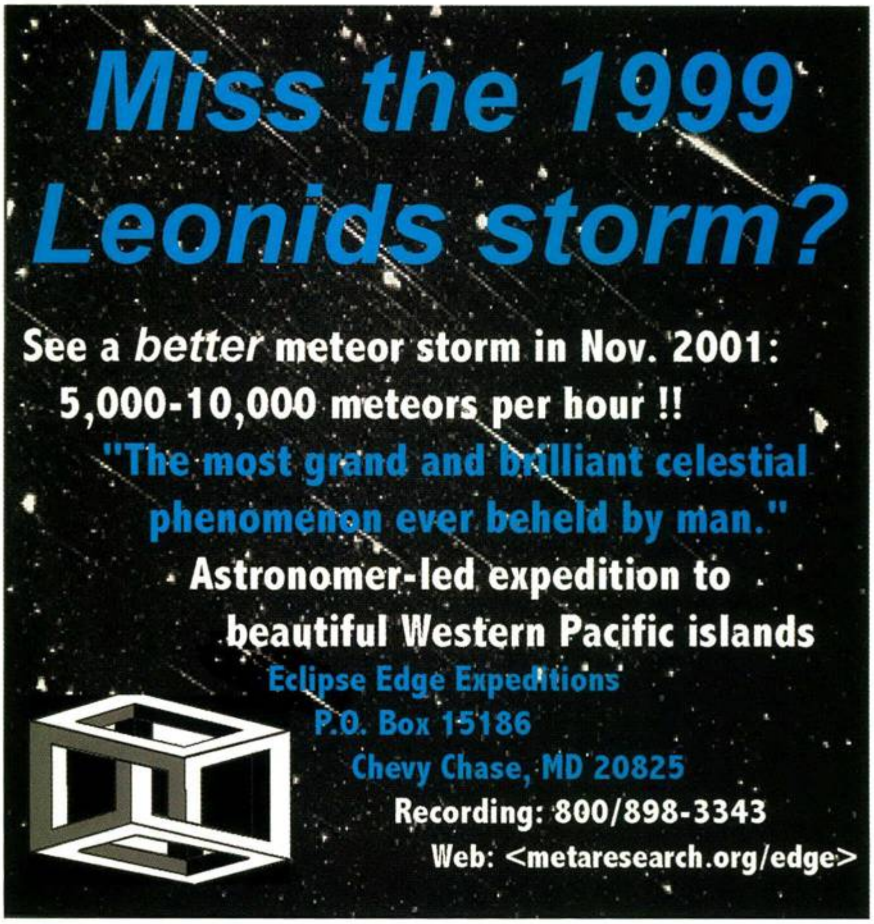
of human bodies and stick figures. What dominates the painting, however, is a large hole in the wall, possibly where a window will go. That opening is dominated in turn by a perfect spiral galaxy seen from directly above one of its poles. A ladder leads up to the bottom of the "window."

"When we explore with our minds," Geller said, "we climb up that ladder into the universe."

We see the universe at two different times, she said. We see what is there today (allowing for light's travel time) at optical wavelengths, and we study the background 3° K microwave radiation to see the universe as it was 200,000 years after the beginning. Working with the 6.5 meter, she said, she and her group will be able to plot all the shape-shifting in between. Instead of a thousand a year, they will plot the positions of several thousand galaxies a night.

At the end of her talk, she turned to Lawrence Small, the new secretary of the Smithsonian Institution, who inaugurated the Distinquished Researcher Lecture series. "I'd like to thank the Smithsonian," she said, "for enabling me to walk among the galaxies." **A**

John P. Wiley is a member of Smithsonian *magazine's Board of Editors and author of* Natural High, *a collection of essays. His special gift is in elegantly presenting science.*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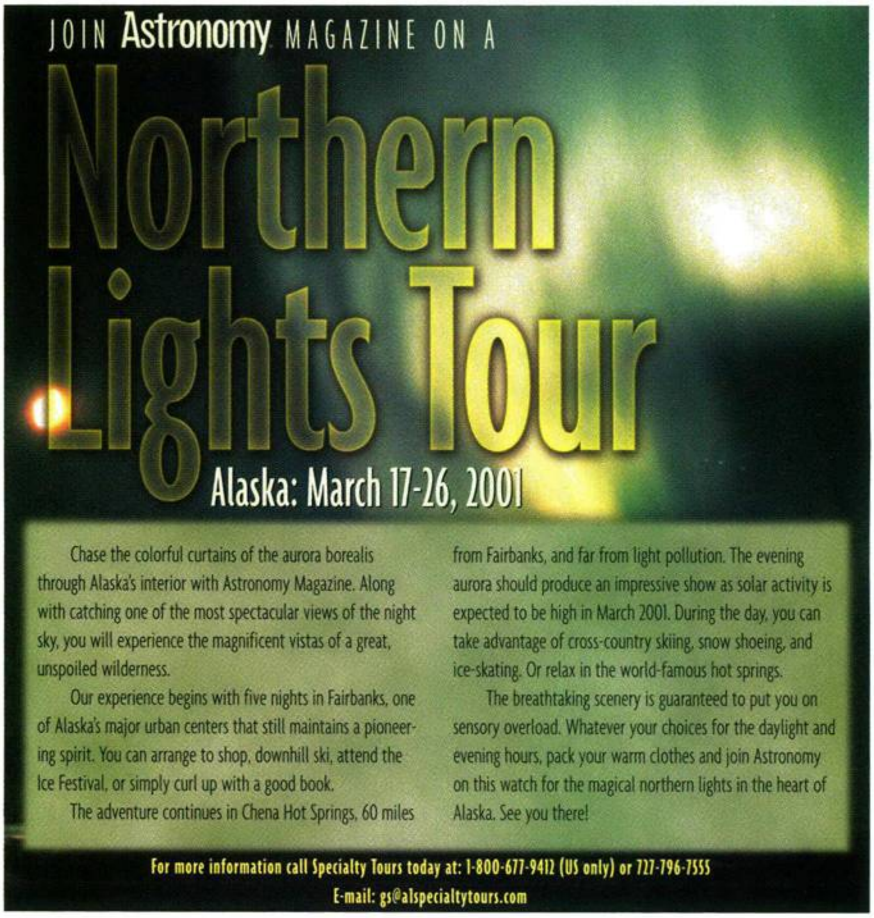
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STAR STUFF

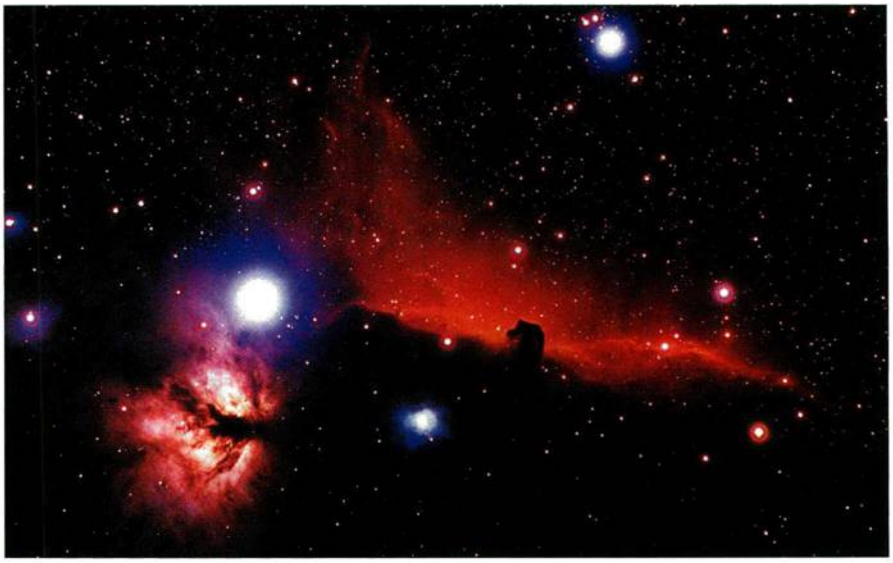
PRODUCTS

Magnificent Constellations

▶ The well-known astrophotography team of Bill and Sally Fletcher is offering a 19-slide set of selected constellations. The wide-field views make use of a special photographic technique that shows the bright star patterns of the constellations in their true colors. The technique also reveals nebulae, stars, galaxies, and clusters within each of the 19 constellations in the "Magnificent Constellations" set.

The images have been featured in magazines, books, and other media worldwide. The slide set includes a laminated information card, made so that the buyer can use it as an easy reference in the classroom or for personal slide presentations. An astronomy overview is included and packaged in a handy folder.

Science & Art Products, 24861 Rotunde Mesa, Malibu, CA 90265; phone, (800) 356-1733 or (310) 456-2496; fax, (310) 456-0728; website, http://www.scienceandart.com. One set, $27.95, two or more sets, $25 each, plus $3.50 shipping (any quantity).



This composite image of the Horsehead Nebula was made by combining a black-and-white photo taken by Rajiv Gupta using a refractor telescope and a color photo taken by Peter Ceravolo with a Maksutov astrograph. *RegiStar* matched the two images and created a composite with the help of the lab color model in Adobe Photoshop.

RegiStar

▶ *RegiStar* is new software that automates the task of aligning digital astronomical images. It finds matching stars, which it uses to precisely align one image with another. The software transforms the tedious process of accurately registering astronomical photographs into a few mouse clicks.

RegiStar shifts, rotates, and deforms as needed. It aligns images created in different scales or orientations, even if they have been produced with different optical systems. RegiStar works on film or CCD images. After two or more astrophotos have been aligned by *RegiStar*, they can be combined in various ways. Small images can be stitched together into a mosaic; photos can be stacked to improve image quality; or high-resolution tricolor images can be created.

The software includes tools to form these composites and also allows for images it registers to be assembled and manipulated using other programs.

Auriga Imaging, 6440 Main St., Vancouver, BC V5W 2V4, Canada; phone, (604) 732-0684; website, http://www.aurigaimaging.com. $149. (There is a 10% discount for members of the Royal Astronomical Society of Canada.)

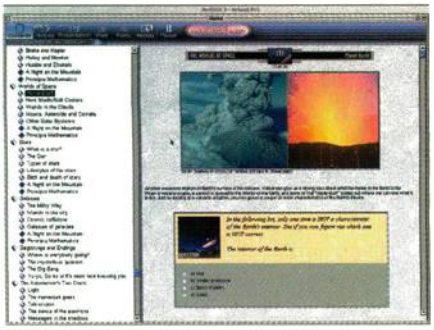
RedShift College Edition

▶ Harcourt College Publishers and Maris Multimedia Ltd. have developed a CD-ROM to be used as a learning tool for college students taking astronomy courses. *RedShift College Edition* includes a combination of interactive simulations, narration, and graphics to guide students and to challenge experienced astronomy enthusiasts.

The two-CD set integrates the planetarium software *RedShift 3* and creates opportunities for laboratory experiences. For example, the software shows how the mass of a Cepheid variable star affects its pulsations.

The CD includes seven chapters that cover ancient astronomy, revolutions in astronomy, planets, stars, galaxies, cosmology, and tools for the astronomer. Also included are 50 guided tours to help visualize basic astronomical relationships and make detailed observations of the night sky.

The software can be used alone or with a number of textbooks, including *Voyages through the Universe* by Andrew Fraknoi, David Morrison, and Sidney Wolff, or *Astronomy: From the Earth to the Universe* by Jay Pasachoff.



Harcourt College Publishers, 150 S. Independence Mall West, Suite 1250, Philadelphia, PA 19106-3412; phone, (800) 245-8744, website, http://www.harcourtcollege.com/store/. $30 ($50 with RedShift workbook).

The Cosmos 3D

Add *The Cosmos 3D* to a growing list of "edutainment" CD-ROMs about astronomy. This Windows-compatible software by MegaSystems Software recently appeared in U.S. retail stores — Best Buy, Media Play, Comp USA, and Micro Center. The move follows releases in Europe of CDs by the company on the human body, animals, Earth, dinosaurs, and technology. "Our philosophy is to provide valuable content of superior quality, depth, and reliability," says Lars Noffke, managing director of MegaSystems. "Ideas are presented in ways that any kid can really enjoy."

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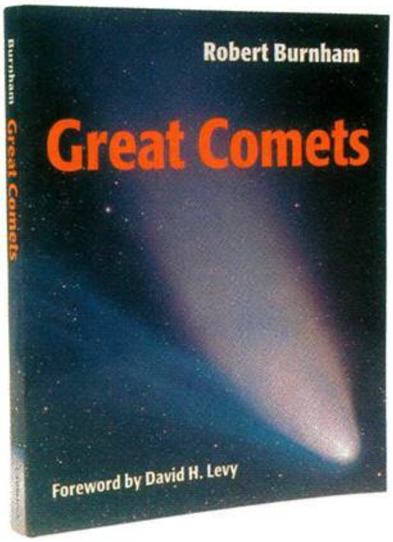
The Cosmos 3D has 580 megabytes of unique 3D animations, 167 illustrations, and 240 pages of easy-to-understand text to help children explore the structure of our solar system and the Milky Way Galaxy. Even the probability of extraterrestrial life is explained. The CD's star navigator helps novice stargazers by presenting views of the sky as it appears through the seasons.

The company calls its 3D line of software intended for the general public its Glasklar Edition. *Glasklar* is a German word meaning "crystal clear," and that is the company's goal. Except for some of the photographs, the content for *The Cosmos 3D* is generated by the Georgia-based company.

MegaSystems, 2150 Northmont Parkway, Suite A, Duluth, GA 30096-5835; phone, (888) 452-7552; fax, (678) 417-6273; website, http://www.glasklar.com. Requires Windows 95 or higher operating system, $39.95.

BOOKS



Great Comets

Robert Burnham, 228 pages, Cambridge University Press, New York, 2000; ISBN 0-521-64600-6; paperback, $21.95.

▶ What made Comet Hale-Bopp one of the greatest comets of recent years? You'll learn the answer to that and a universe of other comet-related questions in *Great Comets*, by former *Astronomy* editor and comet aficionado Robert Burnham.

Burnham, who wrote the 1997 book *Comet Hale-Bopp: Find and Enjoy the Great Comet* begins his latest classic by putting comets in their scientific context. He explains what comets are and where they come from. He follows this discussion by exploring the history and mythology surrounding comets. The word "comet," in fact, comes from the Greek term "hairy star."

Next, Burnham discusses what makes a comet great. David Hughes from the University of Sheffield in Britain and Donald Yeomans of the Jet Propulsion Laboratory in California established the criteria: A great comet has a large nucleus and coma; it has a large, active surface area; it reaches perihelion near the sun; it passes close to Earth; and it provides excellent viewing opportunities for interested Earth inhabitants.

Burnham applies these criteria to recent comets, such as Halley and the disappointing Kohoutek, and the spectacular Hyakutake and Hale-Bopp (he devotes one chapter to each of these undeniably great comets). "A comet can pass very near Earth, as Comet IRAS-Araki-Alcock did in May 1983, yet not reach Great Comet status because it is too small or too inactive," writes Burnham. "And a large comet may never get very close to the sun and yet still be a great comet, as the Great Comet of 1811 did, thanks to its large size and high rate of activity. . . . Each and every comet can almost amount to a case unto itself."

The book moves on to space missions, starting with the 1970 launch of the second Orbiting Astronomical Observatory, which observed Comet Tago-Sato-Kosaka. NASA, the European Space Agency, and the Soviet Union have since launched numerous probes to examine comets, and *Great Comets* covers them all, including the ongoing Deep Space 1 and Stardust missions. It even discusses future comet-research missions scheduled through 2015.

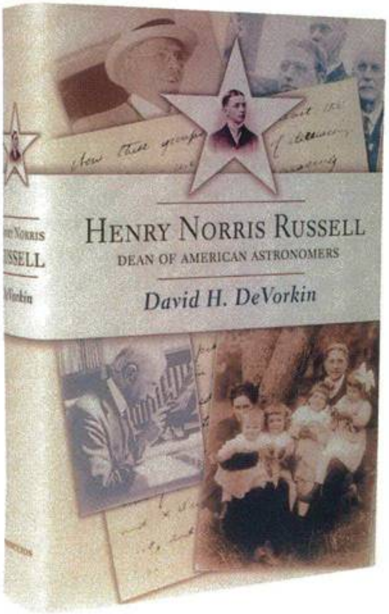
One chapter describes how comets have influenced cultures. Throughout history, comets have fostered widespread hysteria. In 1910, for example, people met Comet Halley's apparition with panic after astronomers announced that Earth would pass through a tail of poisonous gas. If you start chuckling, Burnham reminds you in the following chapter that comets are a legitimate source of concern. Even a small comet impacting Earth could cause global climate changes and extinctions. The final chapter lists websites, books, and print resources for those who want to learn more about comets, stay current on comet appearances, or access information gathered by space probes.

Great Comets is richly illustrated with color photographs taken by professional and amateur astronomers, interplanetary probes, and the Hubble Space Telescope. The reader does not need an astronomical background to appreciate the book. The prose is easy to follow and the beautiful photographs inspire a greater appreciation of these interplanetary wanderers. — *Diane Van Minsel, Sheboygan (WI) Astronomical Society*

Henry Norris Russell: Dean of American Astronomers

David H. DeVorkin, 499 pages, Princeton University Press, Princeton, NJ, 2000; ISBN 0-691-04918-1; hardcover, $49.50.

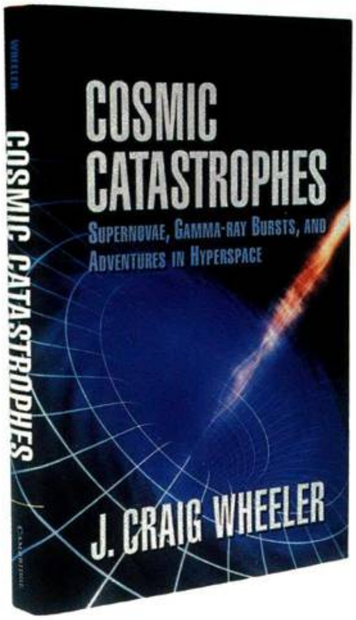
▶ Astrophysicist Henry Norris Russell (1877–1957) was a major figure in the development of American astronomy. In this first full-length biography of Russell, David DeVorkin of the National Air and Space Museum describes in great detail Russell's leadership role in creating a new branch of science: the application of physical theory to astronomical problems.



Russell pioneered the study of stellar evolution and is best known for his codiscovery of the Hertzsprung-Russell diagram (see "Putting Stars in Their Place," page 62). He also developed practical methods for determining physical information of stars in binary systems. The astrophysicist later investigated the spectra of stars, applying the newly developed quantum and atomic physics to determine their properties.

He was one of the first scientists to encourage the interaction of theorists and observational astronomers so that astrophysics could learn from the routine observational work being done at observatories. DeVorkin also describes Russell's leadership role in setting research policy.

The narrative is academic in tone, especially in the chapters devoted to Russell's scientific work. But other parts describe his life and personality. Although detailed at times, this biography will appeal to those interested in stellar evolution, the emergence of American astronomy, and the rise of theoretical astrophysics. — *Christopher Conselice, University of Wisconsin*



Cosmic Catastrophes: Supernovae, Gamma-Ray Bursts, and Adventures in Hyperspace

J. Craig Wheeler, 288 pages, Cambridge University Press, New York, 2000; ISBN 0-521-65195-6; hardcover, $24.95.

▶ If you're eager for a wild ride through interstellar exotica, hop aboard the Craig Wheeler Express. Wheeler, a University of Texas at Austin astrophysicist and an authority on supernovae, derived *Cosmic Catastrophes* from his undergraduate course for nonscience majors called "Astronomy Bizarre." The title is apropos. Starting with just a few simple physical principles, Wheeler explains in cogent language how stars evolve. He uses stellar evolution as a jumping off point to delve into cataclysmic variables, neutron stars, black holes, supernovae, gamma-ray bursts, worm holes, multiple universes, and time travel. Wheeler's narrative is surprisingly easy to follow considering the complex subject matter.

Mars: The NASA Mission Reports

Robert Godwin, editor, 432 pages, Apogee Books, Burlington, Ontario, Canada, 2000; ISBN 1-896522-62-9; paperback, $21.95.

▶ Everything you ever wanted to know about NASA's Mars missions, and then some, is contained within this book. It is the first volume in Apogee Books' ongoing series of NASA Mission Reports that is devoted to robotic missions. Like the other books in the series, it serves as a valuable reference tool rather than a book one would read cover to cover. Most of the book consists of media kits dealing with spacecraft specifications and scientific objectives. The book comes with a CD-ROM, which contains spectacular images and movies from Mariner 9,

The Webweaver Picks

Have you ever wanted to learn more about Copernicus, Kepler, or Annie Jump Cannon for a school paper or simply for your enjoyment? If so, keep these websites in mind:

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The Woman Astronomer homepage is loaded with information and links for anyone interested in the contributions of great female astronomers.
http://users.erols.com/njastro/twa/

The School of Mathematical and Computational Sciences at the University of St. Andrews hosts a website containing biographies of hundreds of mathematicians, many of whom made significant contributions to astronomy.
http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/

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MARS
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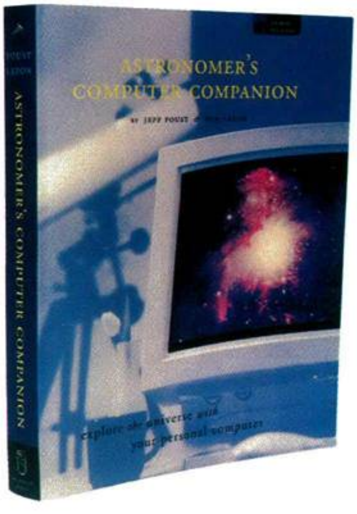
the Viking orbiters and landers, Pathfinder, and Mars Global Surveyor. Mars buffs may find the CD-ROM alone to be worth the cover price.

Astronomer's Computer Companion

Jeff Foust and Ron LaFon, 474 pages, No Starch Press, San Francisco, 2000; ISBN 1-886411-22-0; paperback, $39.95.

▶ Don't expect to actually read this book word for word. Instead, think of the *Astronomer's Computer Companion* as a virtual *TV Guide* for astronomy websites. Skim it for the sites that look interesting. This exhaustive compilation not only gives readers Internet addresses, but also throws in astronomy facts and intriguing trivia along the way. Look for some of the best informational tidbits in the italicized sidebars tucked into the chapters. Foust and LaFon cover every subject from Earth and the other planets to the entire realm of objects in the universe to the latest hobby equipment.



Chapters 14 through 17 and the appendices explore the use of the computer as an astronomical tool. It includes tips for both PC and Mac users. Readers will discover some amazing websites that might otherwise escape notice (unfortunately, some sites have closed down since the book was printed). *Astronomer's Computer Companion* comes with a CD-ROM that contains an electronic version of the book itself, as well as animations, images, and software options. Refer to it in future years as a reference to the electronic universe of astronomy.

MEDIA

Red Planet

Pop diva Britney Spears whirls in a red spacesuit with astronaut actors on a voyage to Mars in a video to her hit song "Oops! . . . I Did It Again." It could be Hollywood's 2000 theme song. Touchstone Pictures gave us the flashy but sappy *Mission to Mars* in March, and Warner Brothers, whose two top-grossing films of 1999 were *The Matrix* and *Wild Wild West*, releases *Red Planet* this month. As author John Gray says, men are from Mars, and it's a hot spot for sci-fi, too.

When a martian mission crash-lands in *Red Planet*, the crew is left without means to escape. Warner Brothers and Village Roadshow Pictures

Warner Brothers calls *Red Planet* "an epic romantic adventure about one crew's intense struggle for survival against the most extreme odds imaginable." With Earth dying in 2050, Mars is being prepared for human habitation when that project fails. Survival of the human species depends on a mission to fix the malfunctioning Mars Terraforming Project.

Of course, the repair mission crash-lands and then, well, let's just say that Mars may look lifeless, but it's not.

Defying orders from Houston, Mission Commander Kate Bowman (Carrie-Anne Moss) refuses to leave a fellow astronaut (Val Kilmer) behind. She tries to guide the stranded crew back while orbiting above them. The film is a blend of Mars Pathfinder, *Saving Private Ryan*, and an R2-D2 that turns against its human crew. The film costars Tom Sizemore, Benjamin Bratt, Simon Baker, and Terence Stamp. *Red Planet* is the directing debut of Anthony Hoffman, a maker of award-winning commercials.

Warner Brothers Pictures, November 3 release: website, http://www.redplanet-movie.com. ▲

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The day before this copy was written, we received 305 cartons from Meade – *3¼ tons* of scopes and accessories in one shipment. Earlier in the same week, we received 9791 pounds of Celestron scopes and accessories in a single shipment – 21 pallets, a full trailer load. We don't know of many dealers – if any – who regularly stock Celestron and Meade products in those quantities . . . *no matter what they claim.* But we do. Telescopes, eyepieces, filters, CCD cameras and autoguiders, dew caps, Barlows, off-axis guiders, illuminated reticle eyepieces, electric focusers, T-adapters, tele-extenders, counterweights – we keep them all in stock.

Buying in such large quantities allows us to take advantage of special buys – extra savings that we pass on to you.

A new low price on the Celestron NexStar 8 . . . and we ship for free!

Here's a deal that doesn't come along very often – a $200 price cut on a popular go-to telescope, *and* free shipping within the 48 continental United States! The sleek Celestron NexStar 8 is powered by AA batteries, so it's portable indeed. It has 8" f/10 Starbright multicoated optics, a go-to computer with an 18,000+ star and object database, eyeglass friendly long eye relief Star Pointer non-magnifying finder, a 40mm NexStar Plössl eyepiece, an AC adapter, a tripod, and more.

Free shipping, a $200 savings, and best of all . . . it's in stock!

Celestron NexStar 8
$1699

The new 8" Meade LX90 lowers the cost of living it up!

Meade 8" LX90
$1695

You can live the good life of big-aperture fully computerized go-to astronomy for less money than ever before with the new 8" **Meade LX90**.

The 8" LX90 SCT is only $1695, including a tripod and a go-to Autostar computer with 30,223 stars and objects in its data base.

We have many, many LX90 scopes on order, so the chances are good that you can get one this holiday season with little or no delay. While backorders *are* possible on this new model, if Meade is shipping the LX90 for a dealer to keep in stock, chances are good we *have* it in stock.

Meade prices are about the same anywhere you call. So why order a Meade telescope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

Visit our redesigned and expanded website, now with secure on-line shopping, www.astronomics.com

We have the Meade ETX-125EC in stock!

Meade 5" ETX-125EC
$895

We have over 100 **ETX-125EC** 5" Maksutov-Cassegrains in stock, with hundreds more scheduled for delivery over the next few months.

We've sold nearly 500 of these 5" computerized Meades during the past year, and 250 of its smaller brother, the 3.5" ETX-90EC. Add in the new 60mm and 70mm ETX refractors, and the Meade ETX scopes make up the most popular family of go-to scopes we carry.

And we don't just have ETX scopes in stock. We have Autostar computers, cases, tripods, eyepieces, electric focusers, filters, camera adapters, and more. If it's any of the Meade ETX scopes, or an accessory for a Meade ETX – *or any Meade telescope* – chances are good that we have it in stock.

3-day air shipping at no extra cost!

We ship by three-day air UPS from our warehouse to our East and West Coast customers at no extra charge above our regular shipping (except for scope cases, Dobsonians, dewshields, and a few other big items). No matter where you live in the 48 continental United States, your order should arrive by the third business day after we ship. UPS can't guarantee 3-day delivery in case of bad weather or during peak seasons, so UPS service guarantees do not apply to this limited time free upgrade if shipments are delayed.

Super second scopes.

Left, Meade ETX-60AT, **$299**; *above,* Meade ETX-70AT, **$349**

The new 60mm **Meade ETX-60AT** and 70mm **ETX-70AT** refractors hit a new low in pricing for fully computerized scopes . . . and a new high in value! For less than the cost of many eyepieces alone, you can have a complete scope – with dual axis motor drives, two eyepieces, built-in go-to computer with 1471 stars and objects in its memory for pushbutton astronomy, and more!

Ideal as starter scopes, as second scopes for casual astronomy, as vacation scopes, as scopes for the kids . . . these Meade scopes are winners!

A CM1400 for how little?

We made another special buy on a large quantity of 14" **Celestron CM1400** Schmidt-Cassegrain German equatorial mount scopes. Normal retail is $5299 *and up*. But, once again, our price is too low to print. You'll have to call us at (800) 422-7876 to find out our low price. The quantity we have available is large, but it's not infinite, so don't miss this sale.

Celestron CM1400, **$????**

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TeleVue? We keep it in stock.

TeleVue TV-85, in stock, **$1995**

Hardly a week goes by that **TeleVue** doesn't send us copies of warranty cards filled with the glowing comments written by our our customers about the TeleVue scopes they bought from us. But we don't need to be reassured about TeleVue quality. We expect nothing but praise for TeleVue, which is why we stock them in depth. As this was written (8/5), we had dozens of TeleVue scopes in stock, *including five TV-101,* three TV-102, five TV-85, four Renaissance, Prontos and Rangers galore, and 45 other scopes on order.

Pronto, **Ranger**, **TV-85**, **TV-101**, the **TV-102** optical tube, the **Renaissance** – all are built to uncompromisingly high optical and mechanical standards. Their short focal lengths give you an observing flexibility many other scopes lack. Each has the ability to go from very low power wide angle views (as low as 9x in some cases, with a wide 5.7° field) to very high power, all without losing optical quality (one test report said they used an amazing 89x per inch of aperture on TeleVue's least expensive model, the Ranger).

In addition to scopes, we stock TeleVue eyepieces, Barlows, mounts, Sky Tour systems, finders, and accessories in depth. If it's from TeleVue, chances are good we have it in stock for immediate shipment.

TMB 80/6	80mm (3.1") f/6 triplet apo	$\$1390^{00}$
TMB 80/7	80mm (3.1") f/7 triplet apo	1390^{00}
TMB 100	100mm (4") f/8 triplet apo	2890^{00}
TMB 105	105mm (4.1") f/6.2 triplet apo	2890^{00}
TMB 130	130mm (5") f/6 triplet apo	4290^{00}
TMB 152	152mm (6") f/6 triplet apo	5990^{00}
TMB 175	175mm (6") f/6 triplet apo	9990^{00}
TMB 180	180mm (7.1") f/6 triplet apo	6990^{00}
TMB 203	203mm (8") f/9 triplet apo	$19{,}890^{00}$
TMB 254	254mm (10") f/9 triplet apo	$34{,}900^{00}$

This Questar costs almost $1000 per inch!

For many people, the mere thought of a 3.5" aperture scope that *starts* at $3395 is enough to curl their toes. But for those who want the best small telescope made, a 3.5" Questar for $3395 is a bargain.

Questar 3.5" Standard **$3395**

Solar filters for eyepiece and finder, built-in Barlow, two ultra-premium eyepieces, a hard case, a star chart on the slide-on lens shade with Moon map beneath – all standard on a Questar . . . and unavailable from the competition.

Want a Questar, the premier portable telescope? We stock them.

> We received a telephone call from ___ _____. She wanted to let us know how helpful you were in providing a telescope when she experienced difficulty with her order from another dealer.
>
> We really appreciate the attention and customer service you provided her. Thank you so much for helping with this matter.
>
> **Customer Quote of the Month #104**
> *(from a letter to us from a magazine publisher)*

CCD? We carry Apogee LISÄÄ, Meade, and SBIG.

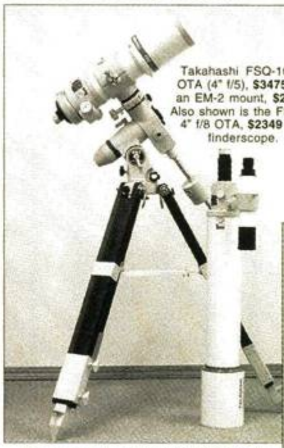
We stock almost all available models of the Apogee LISÄÄ, Meade, and SBIG CCD cameras and auto-guiders (like the new **Apogee LISÄÄ** 659 x 494 pixel guider or imager to the left and the *self-guiding* 1534 x 1020 pixel **SBIG ST-8E** enhanced blue sensitivity imager shown to the right). Our large inventory means the chances are good you won't have to wait to get the camera of your choice. Here are the cameras and guiders we normally keep in stock and their prices.

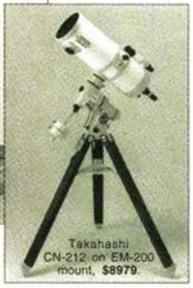
Apogee LISÄÄ	autoguider or camera	$\$1495^{00}$
Apogee LISÄÄ	camera	1395^{00}
Apogee LISÄÄ	color camera	$\$1395^{00}$
Apogee LISÄÄ	megapixel camera	2595^{00}
Apogee LISÄÄ	megapixel color	2595^{00}
Apogee LISÄÄ	guider + color	2690^{00}
Apogee LISÄÄ	guider + megapixel	3890^{00}
Meade 201XT	autoguider	395^{00}
Meade 208XT	autoguider or camera	495^{00}
Meade 216XT	16-bit camera	695^{00}
Meade 416XTE	camera/guider pack	1995^{00}
Meade 1616XTE	camera/guider pack	6495^{00}
SBIG ST-4	autoguider or cameraa	890^{00}
SBIG ST-5C	track/accumulate camera	895^{00}
SBIG ST-237	track/accumulate camera	1195^{00}
SBIG ST-6B	track/accumulate camera	3025^{00}
SBIG ST-7E	self-guiding camera	2950^{00}
SBIG ST-8E	self-guiding camera	7350^{00}
SBIG ST-9E	track/accumulate camera	3950^{00}
SBIG STV	digital video camera/guider	1595^{00}
SBIG STVD	digital video w/LCD screen	1995^{00}

Our Takahashi sales are up 225% this year.

Why are more and more people buying more and more Takahashi from us? Is it because we stock more Takahashi than just about anyone else?

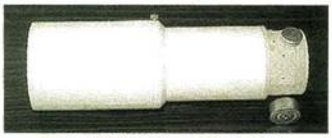
While many people swear *at* the long delivery times quoted by some premium refractor manufacturers, most knowledgeable astronomers swear *by* the unsurpassed optical quality and fast delivery of the Takahashi apochromatic refractors we keep in stock.


Takahashi FSQ-106N OTA (4" f/5), **$3475**, on an EM-2 mount, **$2229**. Also shown is the FS-102 4" f/8 OTA, **$2349** w/o finderscope.


Takahashi CN-212 on EM-200 mount, **$8979**.

From the 2.4" **FS-60C** OTA at $829 to the 6" **FS-152** OTA at $8999, we stock Takahashi fluorite apochromatic doublet refractors, mounts, and accessories – so we can deliver scopes *fast*. We can also special order larger scopes with 1-3 month delivery times. Why wait for 1-3 *years* to get your apo refractor or mount from another manufacturer? You can be usually be viewing through a truly superb Takahashi apo only a few short days after you order from us.

We stock complete Takahashi scopes on USD mounts with dual-axis 50x sidereal slewing, as well as apochromatic optical tubes for use on your own mount.


Takahashi FCL-90 ***Sky 90*** OTA (3.5" f/5.6), shown with dew shield retracted, **$2279**

Arriving this fall is Takahashi's unique **FCL-90 *Sky 90*** 90mm f/5.6 refractor. With its self-storing dew shield retracted, as shown above, this remarkable scope is less than 14" long! Combined with a compact P2Z mount, it makes a great traveller you can stow away anywhere.

We also stock the 22" long Takahashi **FSQ-106N** 4" 4-element f/5 dual fluorite apo refractor OTA, with retractable lens shade, shown to the far left at $3475. It's also a great travelling scope. We had 5 in stock as we wrote this on 8/5.

In stock is the unique Takahashi **CN-212** reflector, shown left on a mid-size EM-200 mount ($6999 on a compact EM-10 mount). It's both a fast 8.3" f/3.9 Newtonian for 35mm and CCD astrophotography *and* an f/12.4 classical Cassegrain reflector for high contrast visual observing.

If you want a great scope, and you want it *now*, your first choice should be a Takahashi from ***astronomics***.

One small step for man. One quantum leap for binocular observing!

"Truly a quantum leap in binocular observing." That's how *Sky & Telescope* reviewed the Canon image-stabilized binoculars. They also said "astounding . . . supercrisp . . . particularly impressive was how well these binoculars compared to much larger apertures . . . " No shake, no blur, no jittery images during hand-held, rock-solid, astronomical observing. The newest versions of the image-stabilized Canon binoculars are the 15 x 50mm, shown, and the higher power 18 x 50mm. A useful option with both binoculars is a pair of specially coated fog-proof eyepieces that help keep the images sharp and moisture-free all night long.

$1499
minimum advertised price

Canon

We stock Pentax eyepieces.

PENTAX

From 5.2mm to 40mm, we stock all of the Pentax wide field (55° to 65°) ED eyepieces. Each has a rotate-to-adjust-the-eye-relief eyecup and a long 20mm eye relief that's perfect for those who wear eyeglasses. Premium eyepieces . . . sensible prices. MAP pricing shown.

7mm (1.25" 65°)	$\$279^{00}$
10.5, 14, 21 (1.25" 65°) **or 28mm** (1.25" 55°)	265^{00}
5.2mm 1.25" 65° or **40mm** 2" 65°	289^{00}

We stock the new Pentax 8.3mm to 25mm 1.25" zoom eyepiece (38° to 60° field). It has a rotate-to-adjust-the-eye-relief eyecup and long 20mm eye relief at all powers (unique among zoom eyepieces) for eyeglass use. MAP pricing shown. .... $\$439^{00}$

A Note About Pricing: since these ads are written several months before the magazines are printed, MAP and other prices currently in effect may not be the same as those shown above. Our website at www.astronomics.com has the latest discount pricing or call us for current pricing.

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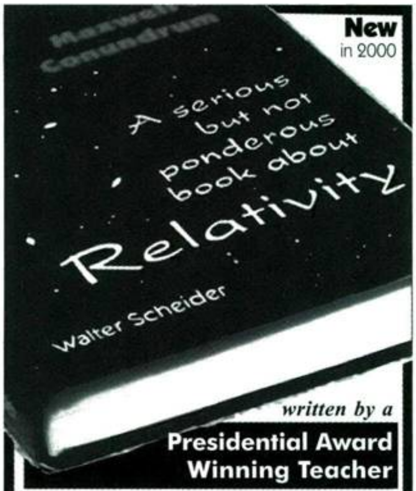

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Finderscope R/A #825			x					52
Interface cord #505	x	x	x	x	x		x	26
Moon filter 1.25"	x	x	x	x	x	x	x	18
Power Package	x	x	x	x	x		x	100
Prism 45° erect #932			x	x				52
Prism 45° erect #933	x	x						52
Rigel Quickfinder	x	x	x	x	x	x	x	40
Skychart CD Rom	x	x	x	x	x	x		55
Solar Filter- glass (90mm)			x					82
Solar Filter- glass (125mm)				x				104
Solar Filter- glass (8")					x			139
Solar Filter- glass (10")						x		159
SCT thread adapter	x	x	x	x				32
Tele extender- mini	x	x	x	x				32
Tripod- tabletop #880	x	x	x					33
Tripod- tabletop #881				x				64
Tripod- deluxe field #882	x	x						100
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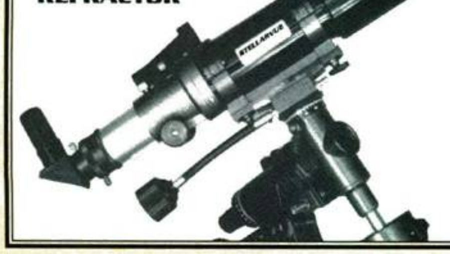

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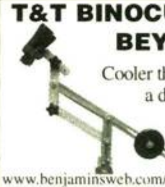

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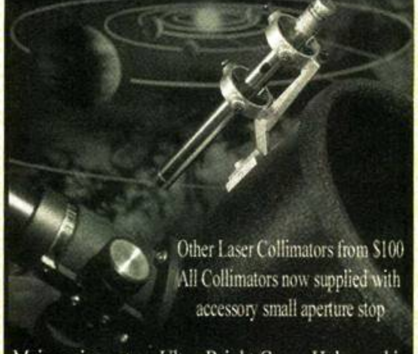

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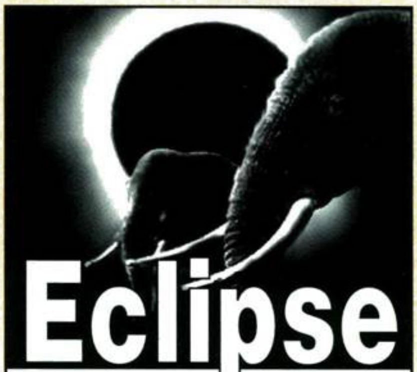

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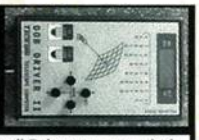

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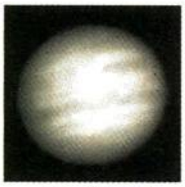

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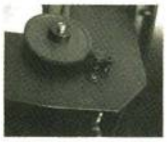
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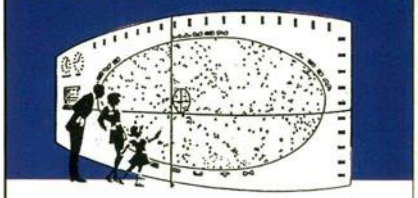

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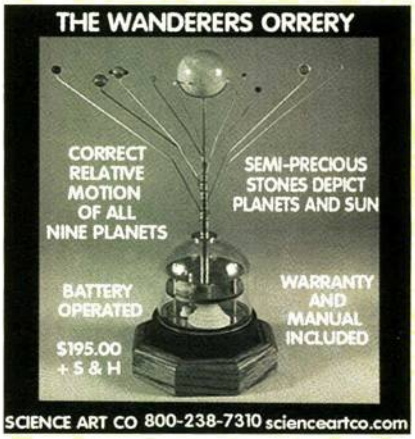
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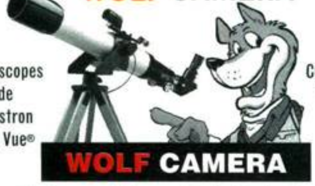

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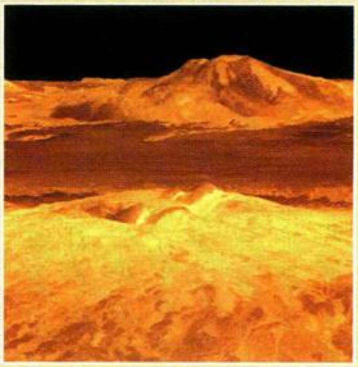
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As the **American Astronomical Society** moves into its second century, it is beginning an exciting new initiative — **The AAS Second Century Lecture Series** — aimed at bringing developments in astronomy to the public. The Second Century Lectures will provide a series of public talks to be given throughout the country in planetaria, science centers, universities, amateur astronomical associations, and any place where public interest resides. Delivered by prominent scientists, the lectures will highlight current astronomical research and present recent findings. The series is planned for four lectures per year continuing over the next several years.

Any institution or organization interested in hosting an AAS Second Century Lecture is encouraged to contact Neta Bahcall (neta@astro.princeton.edu) or David Helfand (djh@astro.columbia.edu). The AAS will support advertising for the lectures and some local venue expenses, if needed, as well as travel expenses for the lecturer.

The next lecture of the series will take place **December 7** at the **National Air and Space Museum** in Washington, D.C. **Neil de Grasse Tyson**, Director of the Hayden Planetarium in New York City, will be speaking on the **Search for Life in the Universe through the Lens of an Urban Astrophysicist**. For more information about this lecture, contact the National Air and Space Museum, (202) 357–2700.

Adler Planetarium and Astronomy Museum Presentations

Chicago, Illinois. **Sears Family Days.** First Saturday of each month, 11:00 A.M. – 3:00 P.M. Free with admission. **Sky Show Presentation: Images of the Infinite: Hubble Space Telescope.** This sky show highlights the history and top science findings of the telescope, as well as taking you on an unforgettable tour through the universe. Open run. **StarRider Theater Shows: Blueprint for the Red Planet.** Presented in the world's first interactive virtual environment planetarium theater, this show invites participants to imagine themselves as settlers on the planet Mars in the year 2030. The settlers will choose the location and architecture for their community as well as enjoy a fly-through of their completed settlement. Showing through November 23. **Journey to Infinity.** This interactive trip through the universe begins on an alien world five billion years ago. Witness the formation of our solar system from gas and dust enriched by star explosions and fly out from Earth into the distant realms of the universe. Open run. For more information, contact (312) 922–STAR; TTY, (312) 322–0995; website, http://www.adlerplanetarium.org.

OCTOBER 26–29

Astrophotography Exhibit — A Pictorial Journey into Outer Space

Kuala Lumpur, Malaysia. This exhibition is hosted by the Star Hunter Astronomical Society of Malaysia. For more information, contact Sua Sin-Zang, e-mail, szsua@tm.net.my or shunter@tm.net.my.

OCTOBER 27–29

Astronomy Camp for Beginning Adults

Mount Lemmon and Bigelow Observatories, University of Arizona, Tucson, Arizona. Contact Don McCarthy, 933 N. Cherry Ave., Tucson, AZ 85721; (520) 621–4079, e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astrocamp.

OCTOBER 27–29

Astronomy Workshop

Skeleton Lake Scout Camp, near Boyle, Alberta, Canada. Contact (780) 458–9345; e-mail, stansey@telusplanet.net; website, http://planet10.v-wave.com/rasc/mainrasc.html.

OCTOBER 27–29

Mount Magazine Star Party

Near Danville, Arkansas. Sponsored by River Valley Stargazers. Contact P.T. Barnum, 76 Observatory Lane, Dover, AR 72837; (501) 331–3620; e-mail, rvstargazer@yahoo.com; website, http://www.geocities.com/CapeCanaveral/Launchpad/2148/starparty.html.

OCTOBER 28

Monthly Star Lecture — Stardust: Supernovae and Life — The Cosmic Connection

Einstein Planetarium, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 6 P.M. For more information, call (202) 357–2700.

OCTOBER 28, NOVEMBER 17

Shreveport Star Party

Ralph A. Worley Observatory, south of Shreveport, Louisiana. Contact Cran Lucas, (318) 797–1524; e-mail, clucas @softdisk.com.

NOVEMBER 3–5

Astronomy Jamboree

Custer Institute, Southold, New York. Sponsored by the Astronomy Group at Custer Institute. Contact Custer Institute, P.O. Box 1204, Southold, NY 11971; website, www.custerobservatory.org.

NOVEMBER 4

Jersey Astro-Conference and Showcase

Union County College, Cranford, New Jersey. Hosted by Amateur Astronomers, Inc. and Union County College. Contact AAI at P.O. Box 111, Garwood NJ 07027-0111; (908) 276–2730; e-mail, jacs@astersim.org; website, http://www.asterism.org.

NOVEMBER 5

Astrofestival and the Planet Field

Ekeberg, Oslo, Norway. Sponsored by the Norwegian Astronomical Society, the Norwegian Association for Young Scientists, and Teknoteket, the National Science Center. For more information, contact Astrofestival, P.O. Box 1029, Blindern, 0316 Oslo, Norway; website, http://www.astro.uio.no/ita/arrangementer/astfest00.html.

NOVEMBER 7

Astronomy Lecture — Leon M. Lederman: As Simple As Possible: The Doing and Understanding of Physics

The National Academy of Sciences, Washington, D.C. 7 P.M. Leon M. Lederman is a Nobel Laureate and Director Emeritus of the Fermi National Accelerator Laboratory. Sponsored jointly by Arts in the Academy and the Office for the Public Understanding of Science, programs of the National Academy of Sciences. For further information, contact Janis Tomlinson at (202) 334–2439 or e-mail, jtmolins@nas.edu.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley @astronomy.com. Look for additional events at http://www.astronomy.com.

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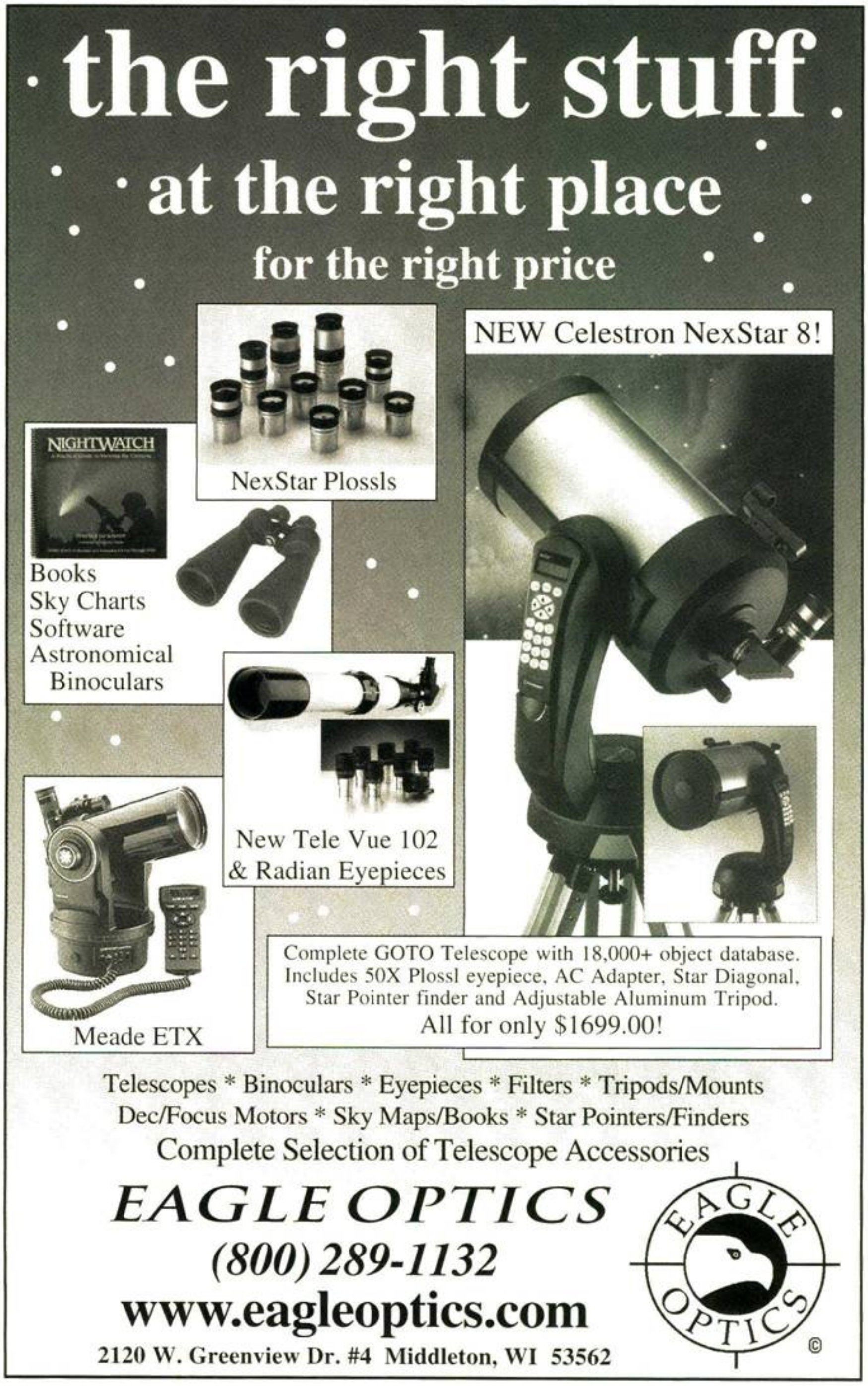

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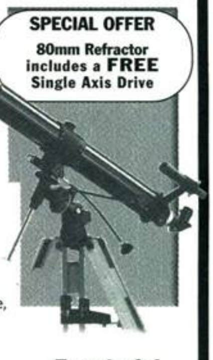

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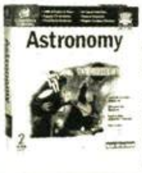

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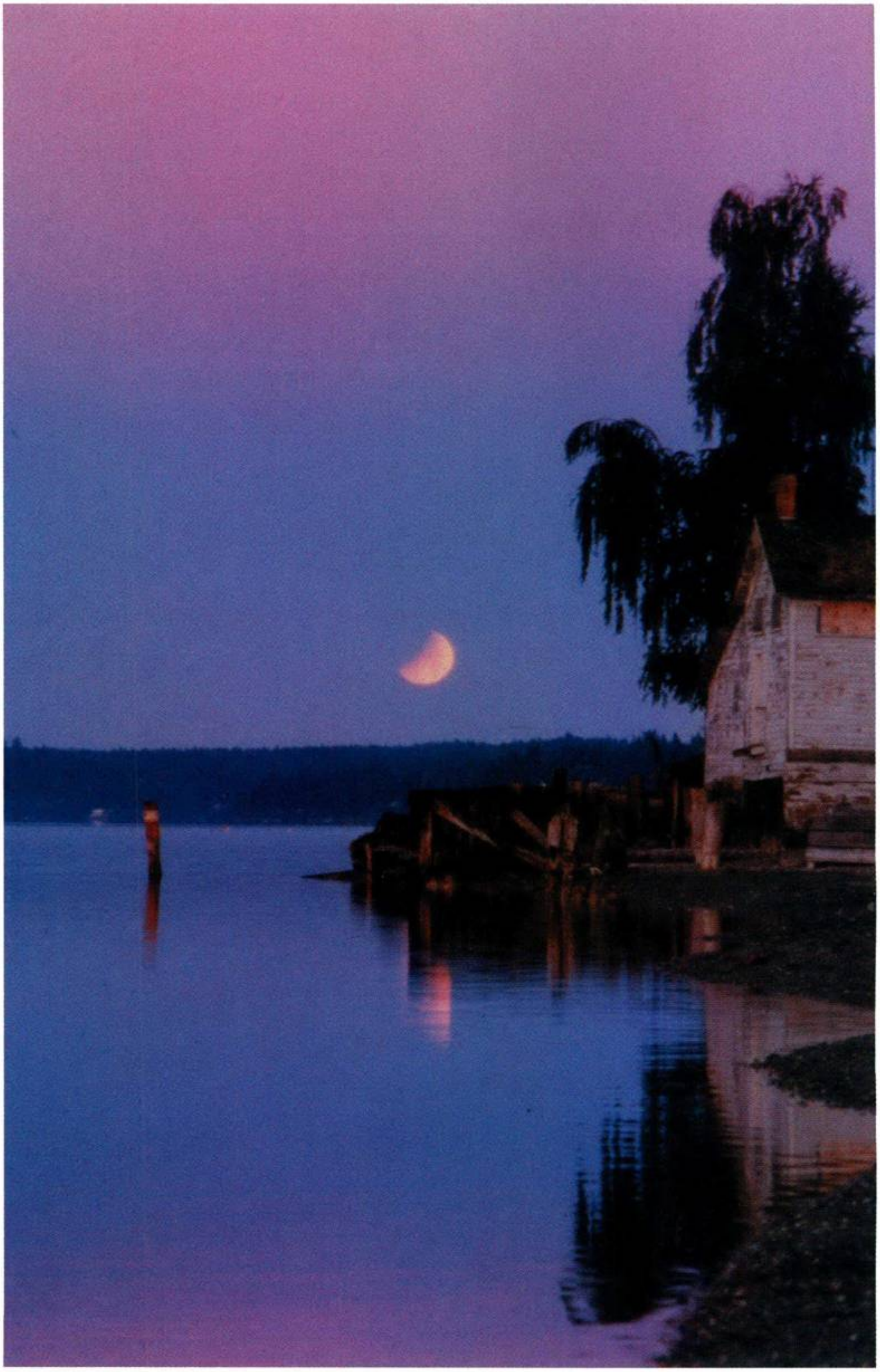
▶ An average of 30 tropical depressions a year visit the Philippines starting in June. Thanks to El Niño, they started a bit earlier this year. By May we already had two tropical hurricanes bringing heavy rains all over the island of Luzon, flooding the streets of Manila. Not a very good time for astronomical observations.

In mid-June, I received an invitation from Marilyn Okuszko, the Supervising Tourism Officer of Iriga City, to give a lecture on basic astronomy to a group of selected students from several of its city schools. I accepted her proposition and set the meeting for Sunday, July 16, in time for the total lunar eclipse that would be visible in the Philippines.

When the day came, a thick band of clouds sat over Manila bringing occasional showers. With my reliable, 5-year-old personal computer, my 14-year-old son Francis, and my friend Evangeline Pascual, I went to the airport and boarded a plane bound for Iriga City.

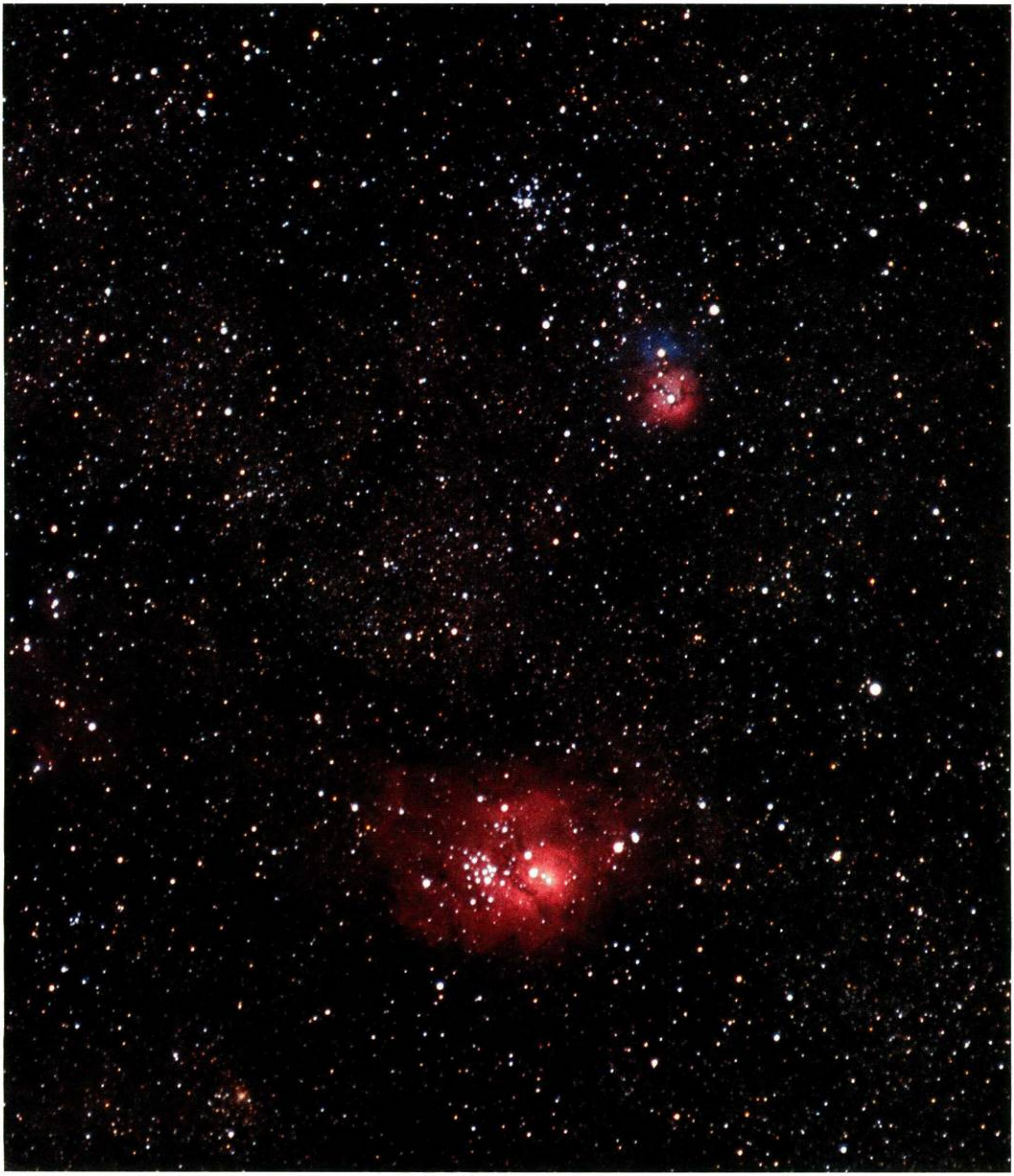
Iriga City is one of the three cities of Bicol Province, 400 miles (650 km) south of Manila. The city is free from smog, dust, and light pollution. It's a very good place for astronomical observations but it currently was not a very



Lunar Eclipse at Dawn

NICHOLAS RISINGER

(150mm lens at f/4, Kodak Elite Chrome 200 film, ½-second exposure taken July 16, 2000, at 6:15 A.M. PDT from Gig Harbor, Washington)



Lagoon and Trifid Nebulae (M8 and M20)

STERGOS MANOLAKAS AND STRATOS KOUFOS

(400mm lens at f/2.8, Kodak GPY 1000 ISO film, 40-minute exposure) good time due to the inclement weather.

That afternoon I lectured about 500 high school students on basic astronomy. The response was so warm that they decided to form an astronomical society.

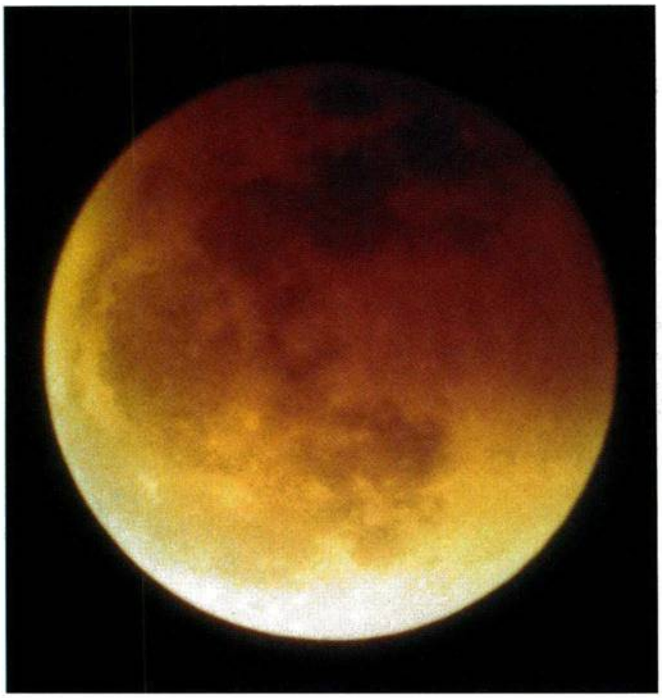
At about 5:30 P.M. we formed a convoy of public buses, school buses, and private cars and headed to the town of Buhi, some 30 minutes from Iriga City, for observing the lunar eclipse. We pitched camp at the Magindara Resort near Lake Buhi. Francis set up the computer. I ran the astronomical software Starry Night Pro, set the location to 13° north and 123° east, locked the position to moon, and set the field of view to 1°. The full moon appeared on the screen and looked quite realistic.

It was almost 6:30 P.M. Miraculously, the clouds disappeared and the full moon became visible.

The students looked alternately at the moon in the sky and the virtual moon on the computer. Starry Night Pro's image was so real that the students thought a camera was connected to the computer. At 6:50 the moon entered the penumbra on the screen. But on the real moon we could only see a slight change of color from silvery white to yellowish white.

We waited. . . .

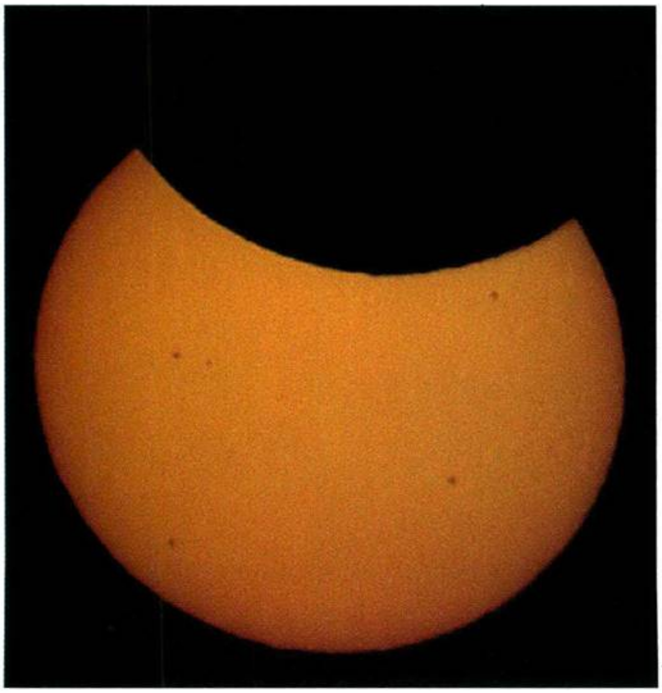
At around 8 P.M. another shadow crossed the moon's surface on the computer — and so with the real one. It was the umbra! Everybody was ecstatic, and so was I, but not so much from the eclipse as from watching the reactions of the teachers and children. It was the first time they had seen such an event and had this kind of a learning experience. I had



The Moon at Mideclipse in Manila

JAMES KEVIN TY

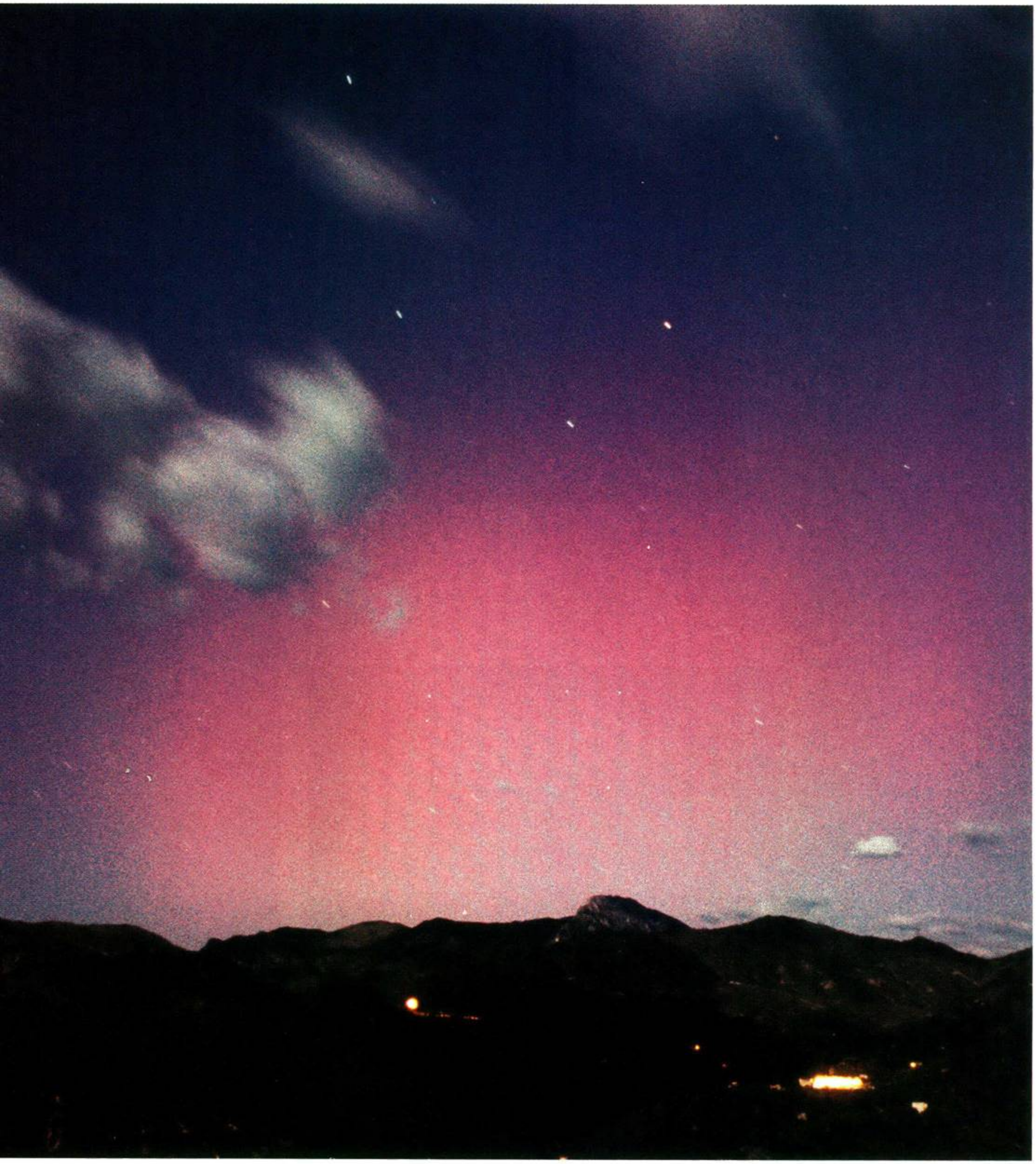
(4-inch f/5.4 refractor, Kodak Max 400 film, 10-second exposure taken 14:27 GMT, July 16, 2000)



Partial Solar Eclipse

JACK NEWTON

(16-inch SCT at f/15, solar filter, Fuji 400 film, taken July 31, 2000, at 7:45 P.M. PDT from British Columbia)



Alpine Aurora

MICHEL BENVENUTO

(28mm lens at f/2.8, Kodak Ektar 1000 film, 120-second exposure taken July 15, 2000, from L'Escarene, France) planted the seed of astronomical interest in them.

It was 9:05 when the moon entered totality. Everybody was happy: Some were singing, others were snacking, others were dancing, one was . . . professing love to his fiancée (no kidding).

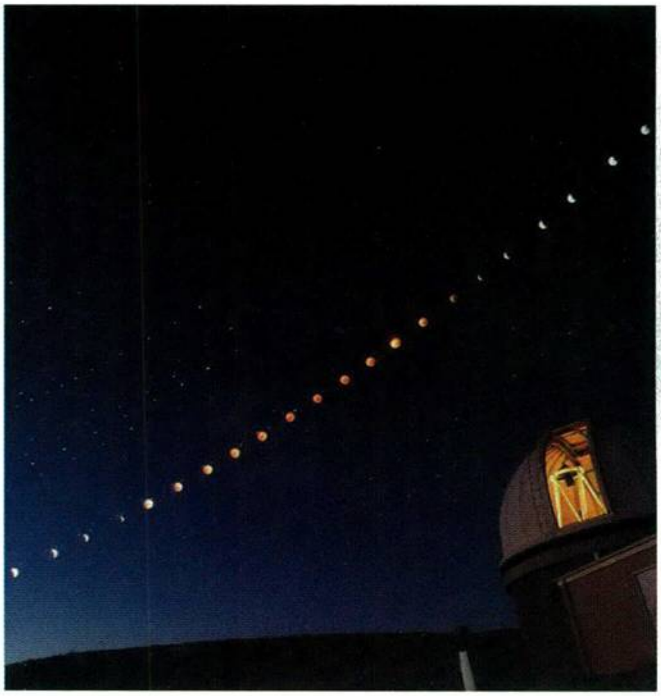
High above in the sky, the real moon was synchronized with the virtual one. "How did you do that?" they asked. "In planetary science almost everything is predictable." I said.

The moon was nearly invisible by about 10 P.M. I showed them Polaris and the stars in the constellations Sagittarius and Capricornus. I pointed out the Milky Way. They had never known that the band of "clouds" above their heads was the Milky Way. They all had thought it was just an ordinary cloud bank.

By 11:45 the umbra was leaving the surface of the moon and we had to cap off the night — except the students didn't want to leave. But it was late for them because the next day was another school day.

The following day, I had an audience with Manny Alfelor, the city mayor. Together with the city architect, we headed to a clearing and discussed a project: to put up an observatory that will house a 16-inch Schmidt-Cassegrain telescope. I met the teachers in the evening. We elected officers and tentatively named the organization Rinconada Astronomical Society. I'll be going back to Iriga in a month. . . . ■

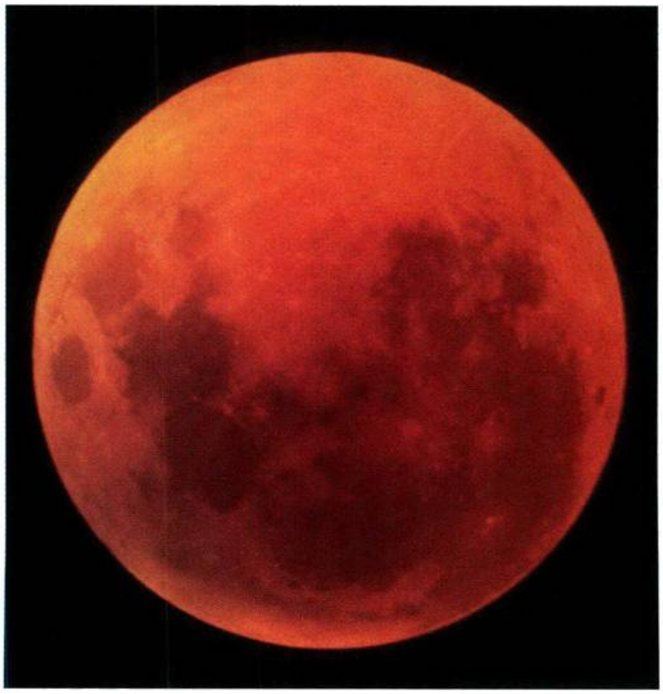
Bernie A. Esporlas is a researcher at the National Museum-Planetarium for the Philippines in Manila.



Lunar Eclipse Stages

JAMES YAN TSE

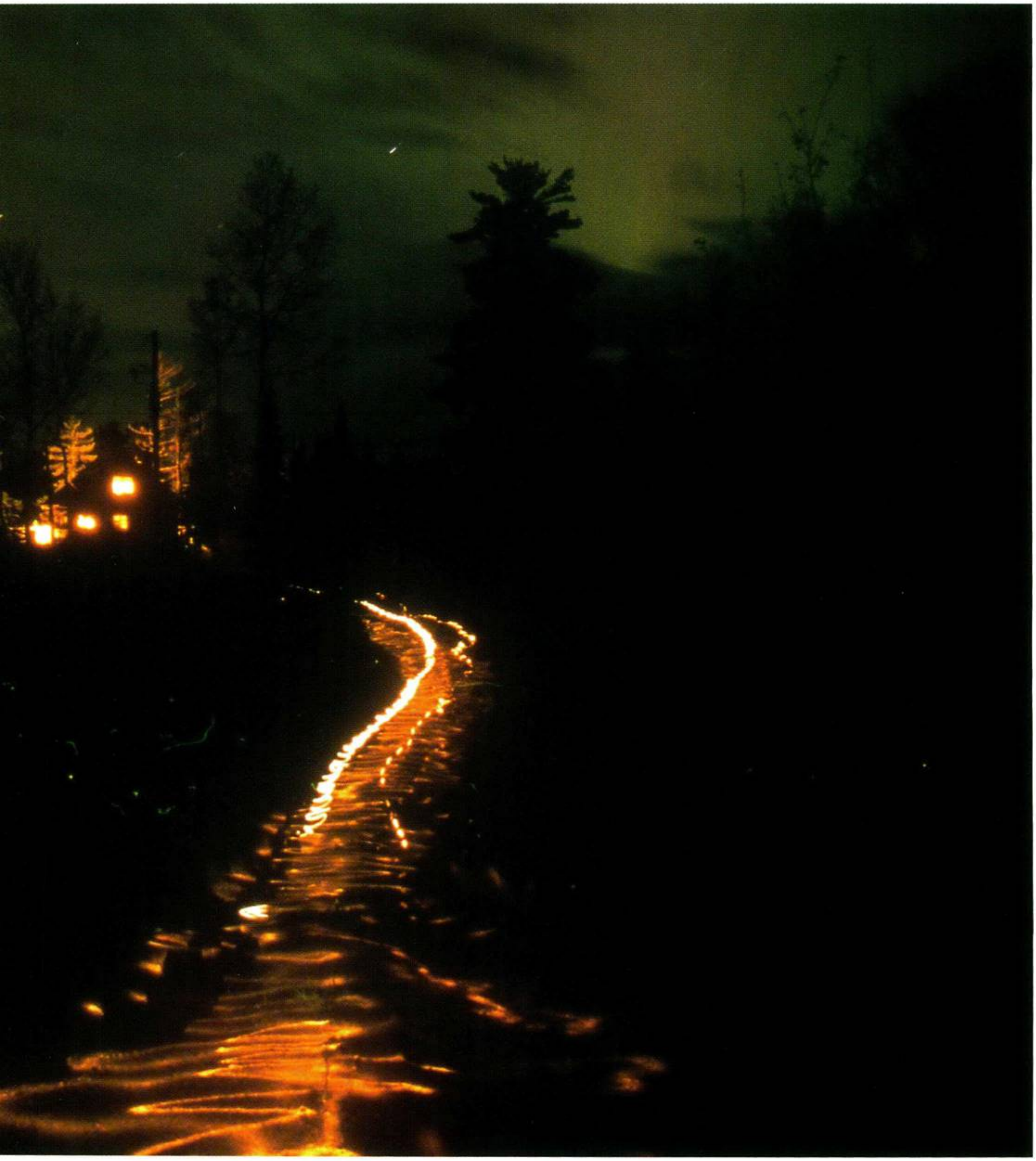
(Lunar eclipse: 28mm lens at f/5.6 to f/11, 9 to 10 minute intervals, landscape and dome: 20mm lens at f/11, 20-second exposure, Fuji 100 ISO film, taken July 16, 2000, at University of Canterbury in New Zealand)



Moon in Shadow

DAVID BOOTTEN

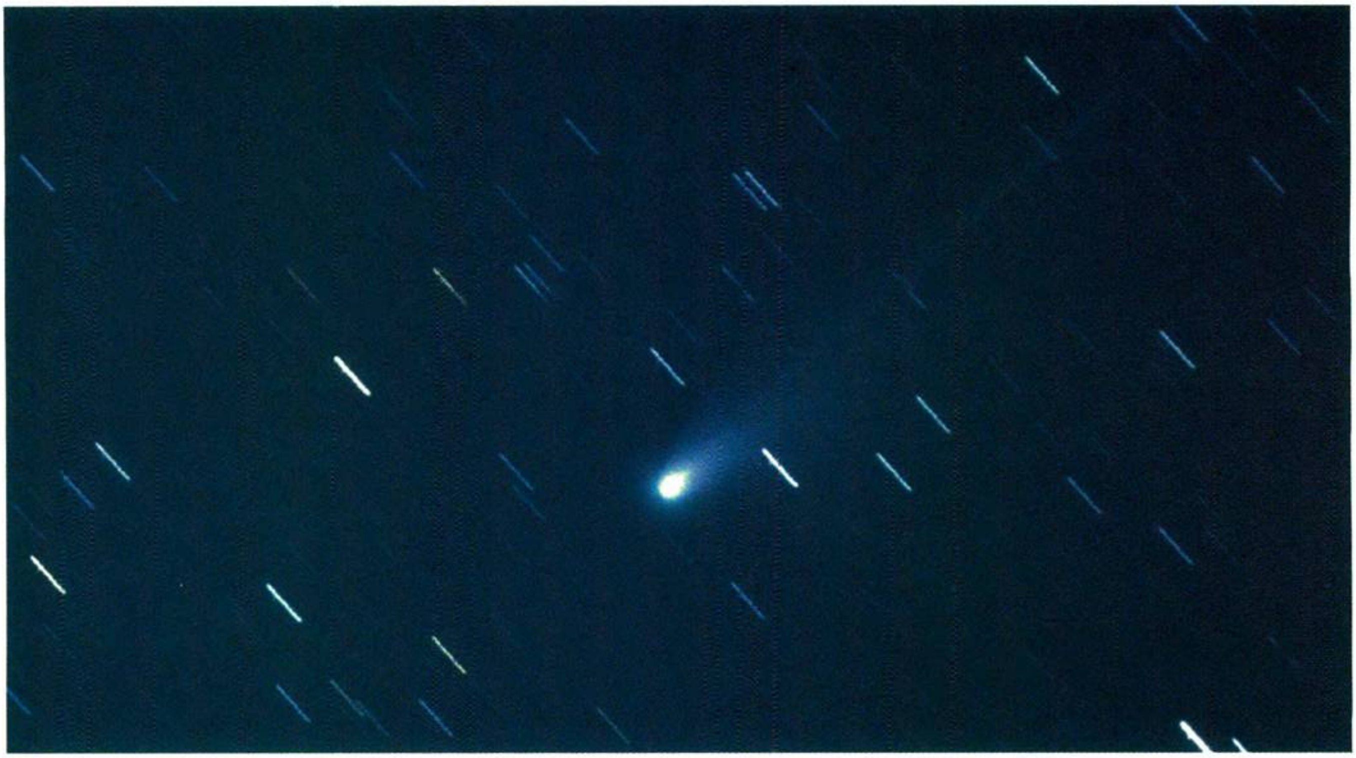
(8-inch SCT, Kodak Elitechrome 400 film, 30-second exposure taken July 16, 2000, from Melbourne, Australia)



Flashlights, Fireflies, and an Aurora

CORY LOEWEN

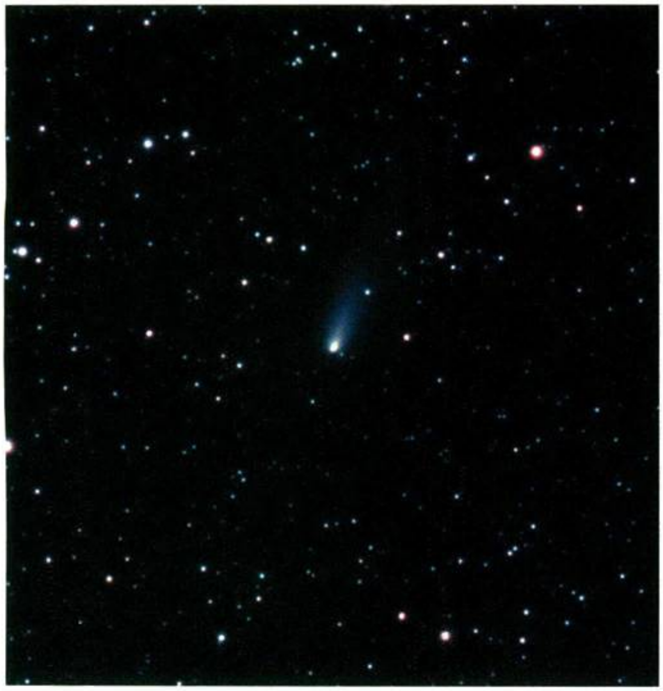
(28mm lens at f/2, Kodak Elitechrome 100 film, 2-minute exposure taken June 30, 2000, from Kenora, Ontario)



Closeup on Comet LINEAR (1999/S4)

ALBERTO LEVY

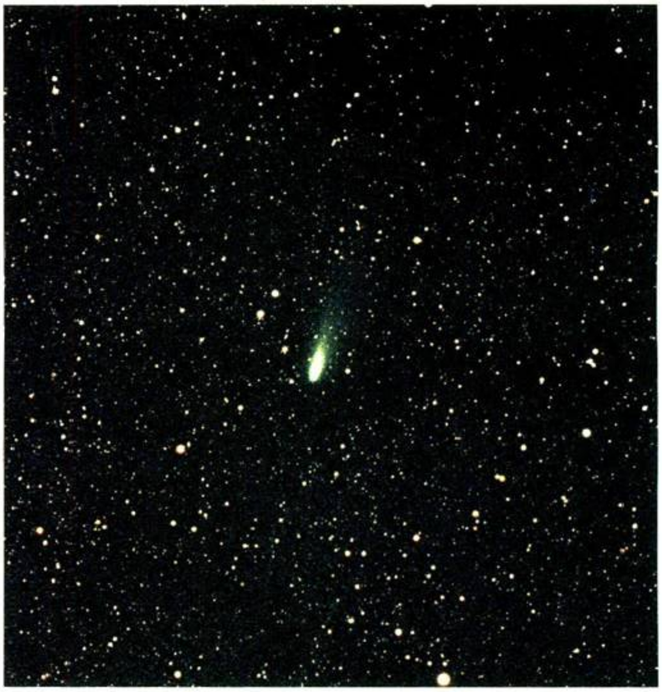
(4-inch f/5 refractor, E-200 hypered film, 15-minute exposure taken July 23, 2000, at 9:52 P.M. PDT)



Comet LINEAR

ALLEN HWANG

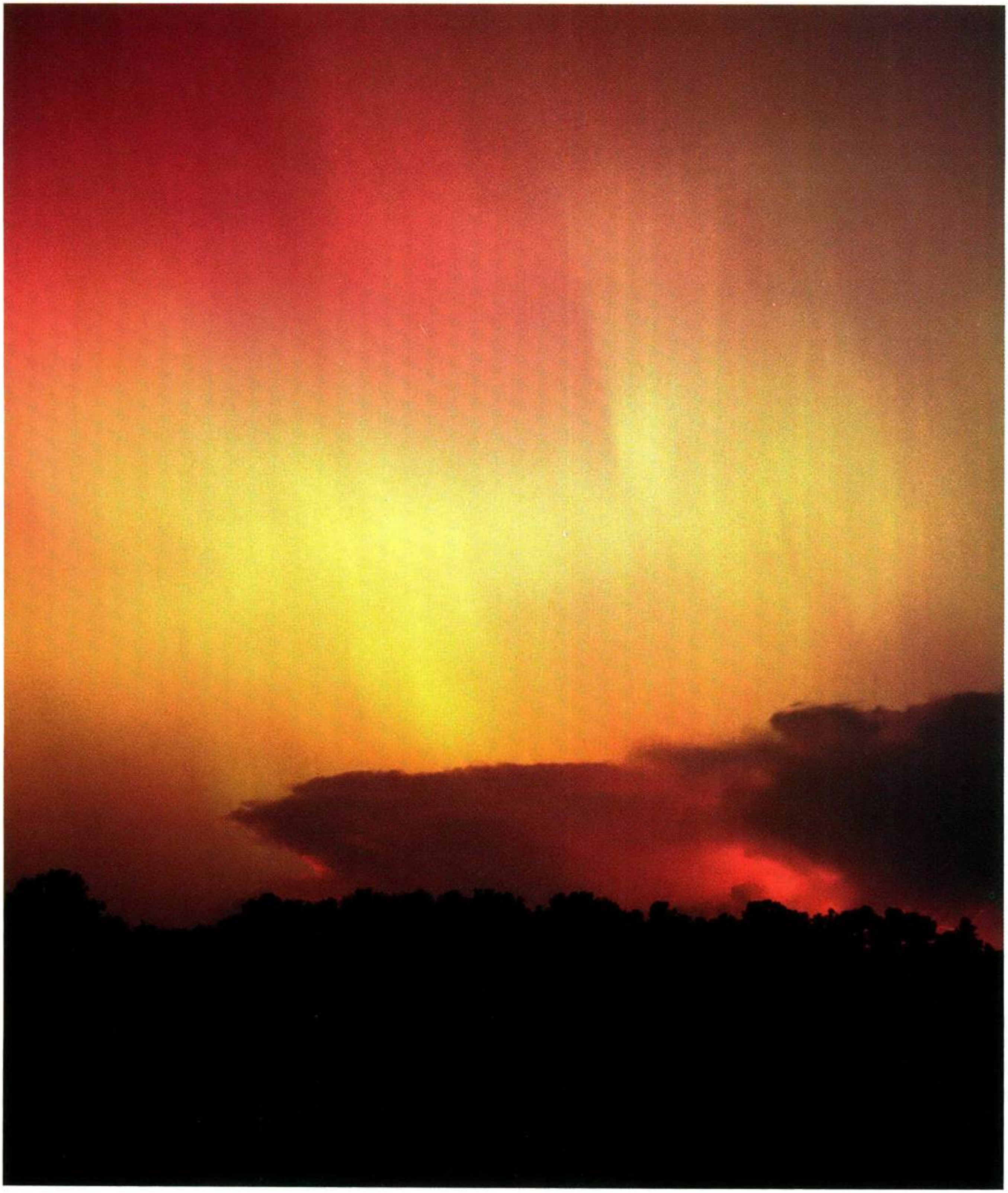
(6-inch refractor at f/5.2, Elitechrome 200 film, 7-minute exposure taken June 29, 2000)



Summer's Snowball (LINEAR)

ALBERTO LEVY

(4-inch f/5 refractor, Fujicolor NPH 400 film, 12-minute exposure taken July 2, 2000, at 2 A.M. PDT)

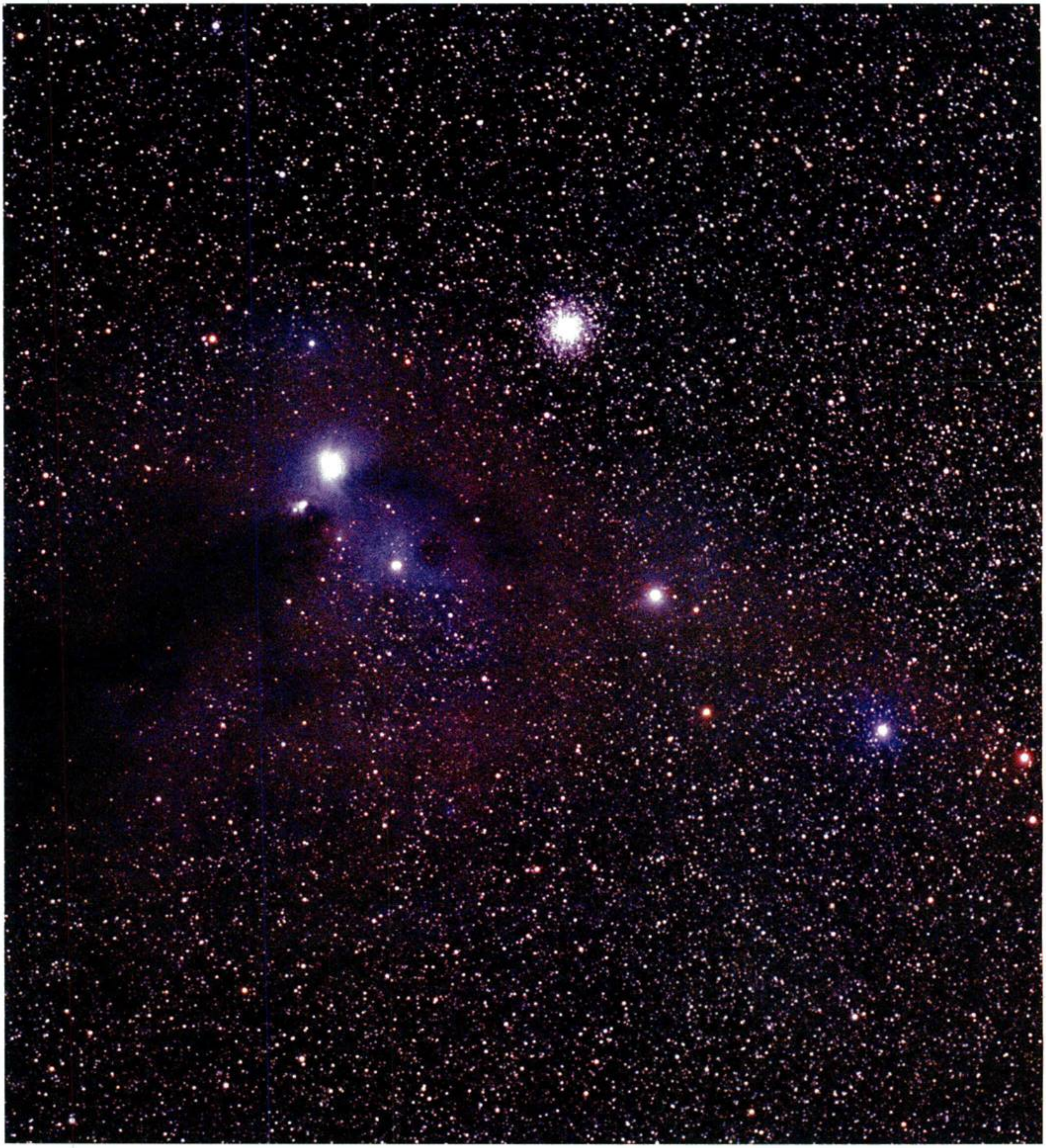


Aurora over an Encroaching Thunderstorm

TIMOTHY SKONIECZNY

(80mm lens at f/2.8, Fuji color NHG II 800 film, taken May 23, 2000)

This month's best astrophoto



Reflection Nebula NGC 6726 and Globular Cluster NGC 6723

GEORGE GREANEY

(6-inch f/7 refractor, hypered 120 format Kodak PPF Pro 400 film, composite of two 60-minute exposures)

This dust cloud lies on the border between Sagittarius and Corona Australis.

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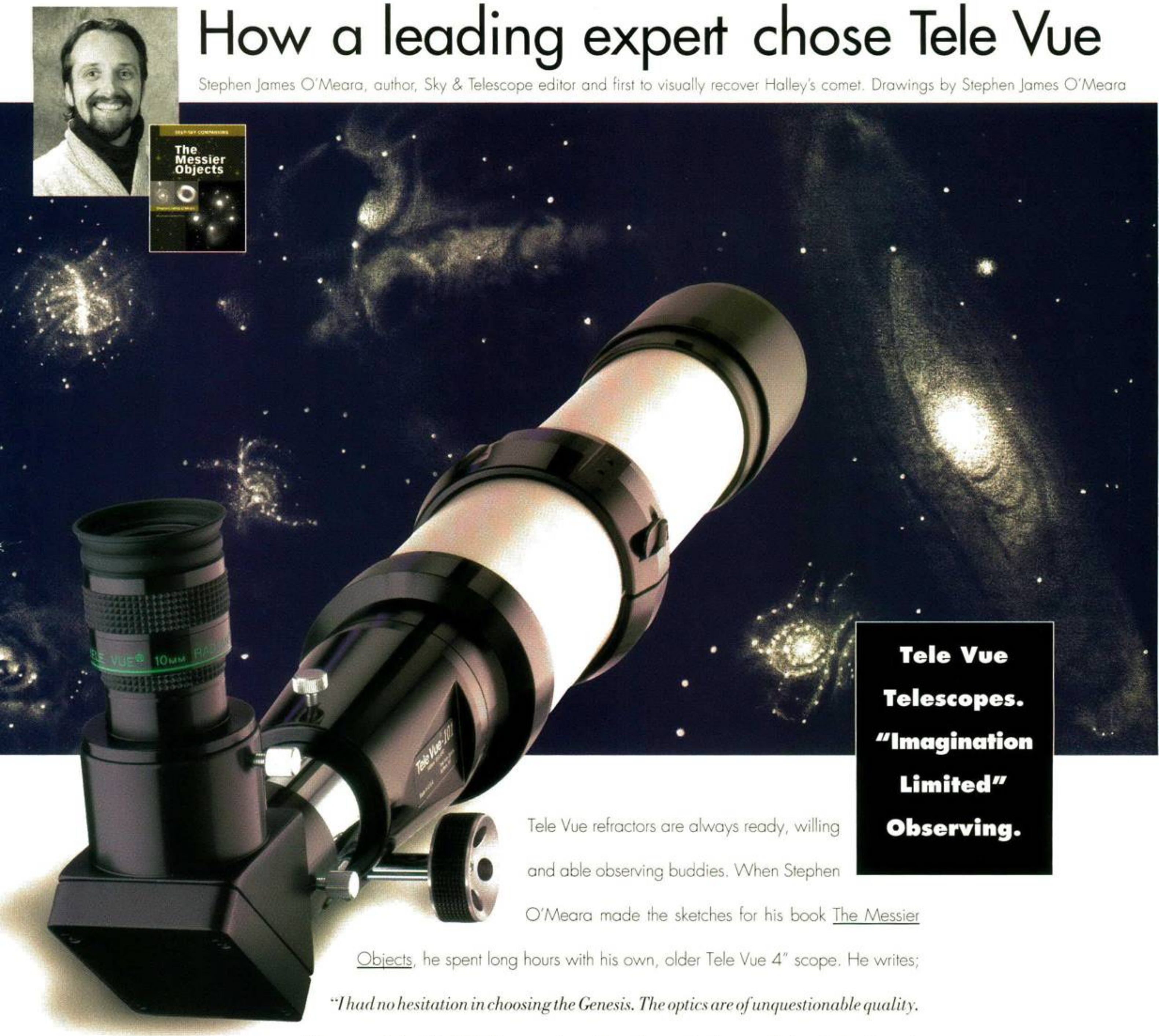

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Tele Vue refractors are always ready, willing and able observing buddies. When Stephen O'Meara made the sketches for his book The Messier Objects, he spent long hours with his own, older Tele Vue 4" scope. He writes; *"I had no hesitation in choosing the Genesis. The optics are of unquestionable quality. When coupled with Tele Vue eyepieces (equally revolutionary designs), the Genesis transcends the traditional limitations of long-focus and rich-field refractors, combining the best qualities of both. Genesis and I met serendipitously under dark Texas skies, where I realized its quality and potential. The rest is history."* Stephen discovered a primary virtue of all Tele Vue scopes - versatile performance. Take one along for "imagination limited" observing.

Tele Vue 101: flat field APO, f/5.4
102: APO, f/8.6

Tele Vue 85: APO, f/7.0

Pronto: 70mm ED, f/6.8

Ranger: 70mm ED, f/6.8

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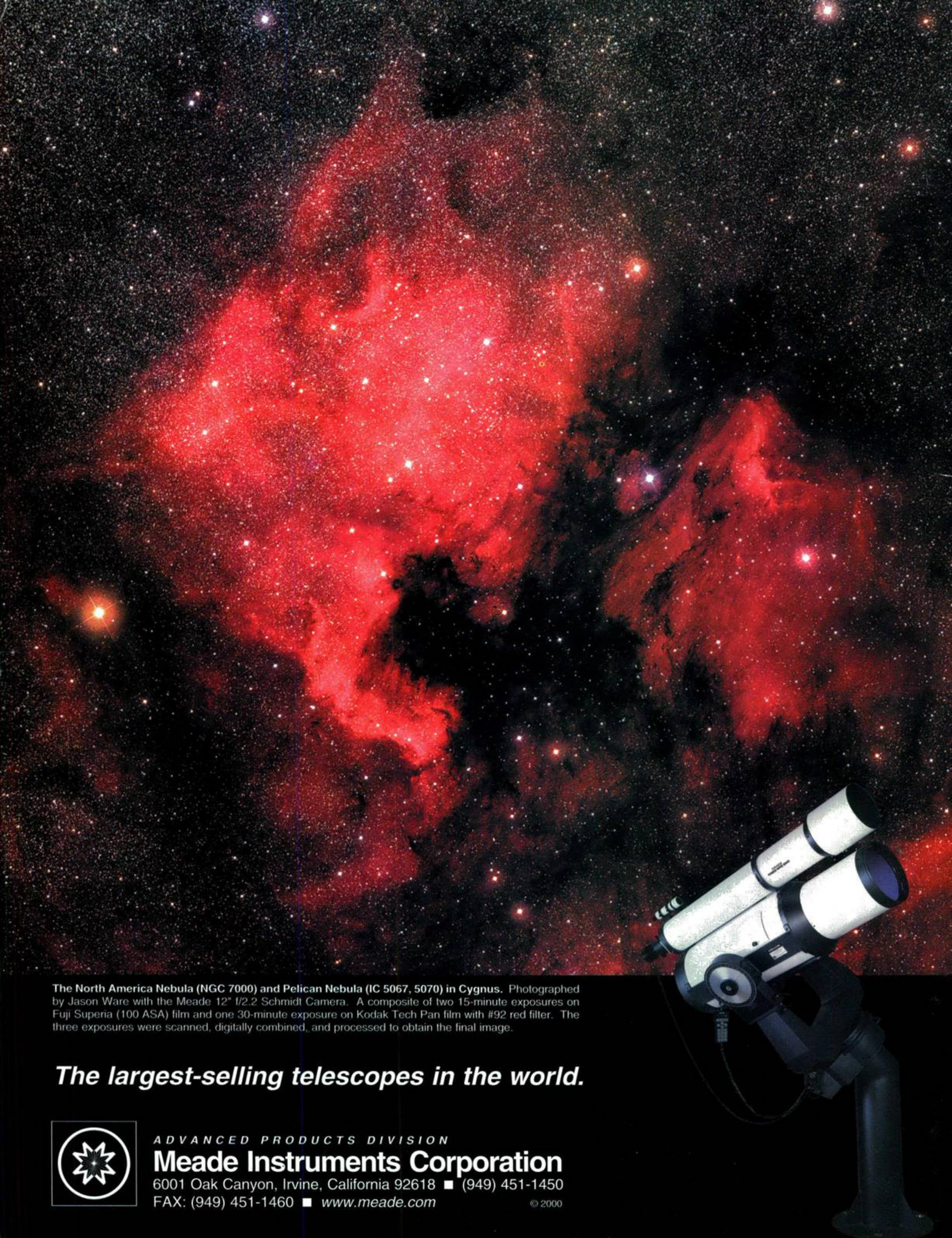

The North America Nebula (NGC 7000) and Pelican Nebula (IC 5067, 5070) in Cygnus. Photographed by Jason Ware with the Meade 12" f/2.2 Schmidt Camera. A composite of two 15-minute exposures on Fuji Superia (100 ASA) film and one 30-minute exposure on Kodak Tech Pan film with #92 red filter. The three exposures were scanned, digitally combined, and processed to obtain the final image.

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